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ANNALS
OF
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Volume XXXI JUNE, 1938 No. 2

NEW SOUTHWESTERN BUPRESTIDAE AND CERAMBYCIDAE

JOSEF N. KNULL,
The Ohio State University,
Columbus, Ohio

Acmaeodera jaguarina n. sp.

Male.—Robust, elongate, surface above and below bronze, above moderately pubescent, clothed with flattened white scales, each elytron with six small, irregular yellow markings, beneath densely clothed with flattened white scales.

Head depressed, coarsely punctured; antennae extending beyond middle of pronotum when laid along side margin, serrate from the fifth joint.

Pronotum not quite as wide as elytra at widest point, wider than long, wider at base than at apex; sides broadly rounded in front, more acutely rounded posteriorly; disk convex, slight median impression in front of scutellum; surface with closely placed punctures separated by about half their own diameters, pubescence recumbent, scales obscuring part of surface. Scutellum inconspicuous.

Elytra with prominent umbones; sides acutely rounded at base, strongly constricted back of humeral angles, broadly rounded posteriorly to rounded apices; margins serrate on apical fourth; disk convex; surface coarsely striately punctured, intervals flat, containing single rows of closely placed punctures from which arise recumbent hairs, scales obscuring part of surface.

Abdomen beneath with sculpture obscured by white scales, last ventral segment without apical ridge. Front margin of prosternum truncate, sides nearly reaching the front angles.

Length 5.3 mm.; width 1.7 mm.

Female.—More robust than the male, last three ventral segments densely finely punctate, clothed with long fine hairs which curve forward.

Holotype male and *allotype* labeled Yuma, Arizona, August 8, 1936, collected by the writer. Paratypes from the same

locality include, June 12, 1934, E. D. Ball and June 10, 1937, D. J. and J. N. Knull. Type material in author's collection.

This species would stand next to *junki* Thery. in the Truncatae group, according to Fall.[1] However, it is more slender, pronotum less transverse and more densely punctured, pubescence of intervals longer and more pronounced.

Acmaeodera mimicata n. sp.

Male.—Robust, convex, elongate, surface above dark bronze, lighter and more shining beneath, clothed with elongate scales which are more numerous on ventral surface, each elytron with six irregular yellow markings.

Head convex, punctures large, light; antennae reaching to beyond middle of pronotum when laid along side margin, serrate from the fifth joint.

Pronotum not quite as wide as widest part of elytra, wider than long, broader at base than at apex; sides broadly rounded in front, subparallel at base; disk convex; surface with large, shallow punctures which are more numerous toward sides, pubescent at middle, clothed with white scales. Scutellum inconspicuous.

Elytra with prominent umbones; sides strongly rounded in front, constricted back of humeral angles, parallel in middle, broadly rounded posteriorly to rounded apices, margins serrate from middle; disk convex; surface coarsely striately punctured, intervals with single rows of small punctures from each of which arises an elongate white scale.

Abdomen beneath densely punctured, clothed with white scales, last ventral segment without apical ridge. Front margin of prosternum deeply emarginately lobed at middle, the front margin at sides not reaching the angles.

Length 6.3 mm.; width 2 mm.

Female.—More robust than the male, last three ventrals not modified.

Holotype male labeled Congress Junction, Arizona, June 14, 1937, *allotype* and *paratypes* labeled Tucson, Arizona, June 8, 1937, D. J. and J. N. Knull, collectors. Type material in writer's collection.

This species, which resembles a denuded *A. junki* Thery., would probably better be placed in the Lobatae group according to Fall.[1] It resembles *A. pinalorum* Knull, from which it can be separated by the presence of white scales on the elytra instead of regular pubescence. The prosternal lobe is also more deeply emarginate.

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[1]H. C. Fall, Jour. N. Y. Ent. Soc., VIII, pp. 1–37, 1899.

Hesperorhipis hyperbolus n. sp.

Male.—Head, pronotum and basal areas of elytra dark metallic blue varying to green, tips of elytra dark blue, each elytron bearing a transverse white band which is diagonal from side margin to suture posteriorly, leaving dark triangular area at scutellum and dark humeral angle; ventral surface dark metallic blue.

Head convex, slight depression on vertex, surface crenulate; eyes small, finely granulate; antennae testaceous, extending to middle of elytra when laid along sides of pronotum, flabellate, quite similar to those of *H. mirabilis* Knull figured by me,[2] scape elongate, stout, second joint stout, over twice as wide as long, rami beginning with the third joint; last joint of maxillary palpus narrowed apically, truncate.

Pronotum wider than long, narrower in front than at base; anterior margin sinuate, median lobe rounded; basal margin slightly sinuate; lateral margins inferior in front, present in basal half only; sides arcuate; disk convex, without depressions or callosities; surface reticulate. Scutellum, dark blue, glabrous.

Elytra wider than widest point of pronotum, not covering the abdomen, tips extending to third ventral abdominal segment; sides nearly parallel in front, constricted back of middle, broadly rounded posteriorly to obtusely rounded apices, finely serrulate back of middle; sutural margins divergent posteriorly; surface rugose, light area void of rugae except along side margin and suture, this area finely punctured; under wings extending to beyond end of abdomen.

Abdomen beneath coarsely punctured, last segment broadly emarginate; sides of metasternum with a large hairy depression, or excavation; basal joint of hind tarsus equal in length to the three following joints.

Length 5.3 mm.; width 1.7 mm.

Described from specimens collected from oak at Prescott National Forest, June 21, and Hualpai Mountains, Arizona, July 2, 1937, by D. J. and J. N. Knull. *Holotype* labeled Prescott National Forest, June 21, and *paratypes* in writer's collection.

I have considered this a *Hesperorhipis* in view of the fact that the rami actually start with the third antennal joint. It fits part of this genus and also *Xenorhipis* as contrasted by Prof. Fall.[3]

The species differs from *H. albofasciatus* Fall in having an excavation on the metasternum and it can be separated from *H. mirabilis* Knull by the longer elytra, larger white area and the shape of the second antennal joint.

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[2]J. N. Knull, Ohio Jour. Sci., 37, p. 309, 1937.

[3]H. C. Fall, Pan-Pacific Ent., 7, p. 75, 1930.

Chrysobothris parapiuta n. sp.

Male.—Resembling *C. piuta* Wick. in color and form; front bright green, vertex and anterior portion of pronotum reddish cupreous, base of pronotum, elytra and ventral surface bronzed, a violaceous luster on each elytron.

Head convex; surface coarsely punctured, punctures more numerous near epistoma, front moderately pubescent, a median line extending over vertex, a smooth callosity on either side of front; clypeus broadly emarginate; antenna not reaching middle of pronotum when laid along side margin, serrate from the fourth joint, serrate joints of about equal width, second joint slightly longer than wide, third joint as long as following two taken together; upper lobe of eye slightly more broadly rounded than lower one.

Pronotum broader than long, narrower at base than at apex; sides broadly rounded in front, subparallel in middle, constricted at base; lateral margin entire; disk convex, a well marked fovea on either side at base; surface coarsely punctured, punctures becoming smaller and more numerous on either side at base and along lateral margins. Scutellum triangular, granulose.

Elytra distinctly wider than thorax; sides acutely rounded in front, parallel to apical third, broadly rounded to rounded apices; margins serrulate from middle; disk convex, each elytron with two foveae at base, one in middle one-third length of elytron from base, another indistinct one back of middle near outer margin, costae indistinct; surface coarsely punctured. Ventral surface conspicuously pubescent along median line. Abdomen coarsely punctured, moderately pubescent, last segment with serrulate margins, tip broadly emarginate. Prosternum plainly lobed. Anterior femur with indistinct tooth, serrate toward apex, tibia arcuate, broad sinuate dilation on inner side at tip extending about one-fourth length of tibia, middle and hind tibiae straight.

Length 5.5 mm.; width 2.2 mm.

Female.—Differs from the male by having entire head reddish cupreous, last ventral with small deep emargination, anterior tibia not modified and lacking the median line of pubescence on ventral surface.

Described from specimens collected by D. J. and J. N. Knull at the following localities in Arizona: Wickenburg, June 18; Prescott National Forest, July 29, 1937. *Holotype* male and allotype from Wickenburg in the collection of the writer.

This species belongs to Horn's[4] group I and should stand next to *C. piuta* Wick. It can be separated by the less prominent tooth on the anterior femur and by the shape of the male genitalia.

---

[4]G. H. Horn, Trans. Amer. Ent. Soc., 13, p. 65, 1886.

Agrilus sapindi n. sp.

Male.—Form robust, bright metallic green above and beneath, void of markings or conspicuous pubescence on dorsal surface.

Head depressed, a line extending from vertex to middle of front, surface coarsely punctured on vertex becoming rugose above clypeus, pubescence inconspicuous; antennae not quite reaching middle of pronotum when laid along side margins, serrate from the fourth joint, serrate joints longer than wide.

Pronotum wider than long, wider at base than at apex; side margins broadly rounded in front, sinuate near base, when viewed from the side the marginal and submarginal carinae are separated for their entire length; anterior margin sinuate, median lobe quite broad; basal margin strongly emarginate at middle of each elytron; disk convex, lateral depressions feeble, median depression and prehumeral carinae absent; surface transversely strigose, small punctures between strigae. Scutellum rectangular, transversely carinate, glabrous.

Elytra at base, narrower than base of pronotum; side margins rounded in front, constricted at middle, apices rounded, serrulate; disk convex, sutural margin elevated posteriorly, basal depressions well marked; surface imbricate, punctures inconspicuous.

Abdomen beneath transversely imbricate, finely punctate; first two segments not modified at middle, suture between first two segments plainly indicated at the sides; pygidium coarsely punctured, carinate, the carina not reaching margin. Prosternum rugose, pubescence short; prosternal lobe truncate; prosternal process broad, sides parallel to behind coxal cavities. Tibiae of first two pairs of legs mucronate on inner margin at apex. Posterior tarsi shorter than the tibiae. Tarsal claws similar on all feet, cleft, the inner tooth broader than the outer one and turned inward, the points touching.

Length 10.6 mm.; width 3 mm.

Described from two male specimens collected from the foliage of soapberry (*Sapindus drummondi* Hook & Arn.) in the Davis Mountains of Texas, June 2, 1937, by D. J. and J. N. Knull. *Holotype* and *paratype* in writer's collection.

According to Fisher's[5] key this species would run to *A. arcuatus* Say but it can be separated from this species by the absence of prehumeral carinae. The genitalia are also distinct.

Agrilus apachei n. sp.

Male.—Form small, narrow, elongate, dark bronze on both surfaces, parts of legs, prosternum, vertex of head, pronotum and an elongate area back of humeral angle cupreous, front bright green.

Head convex, front with longitudinal depression extending to vertex; surface coarsely punctured, rugose; antennae extending three-

[5]W. S. Fisher, U. S. Nat. Mus. Bul. 145, pp. 1–349, 1928.

fourths the length of pronotum when laid along side margins, serrate from the fifth joint.

Pronotum wider than long, base and apex of about equal width; side margins broadly rounded in front, sinuate at hind angles; when viewed from the side the marginal and submarginal carinae separated for their entire length; disk convex, a well marked depression extending entire length, lateral depressions not well defined, prehumeral carinae lacking; surface transversely rugose in middle, obliquely at sides, fine punctures between rugae. Scutellum granulose, transversely carinate.

Elytra as broad as widest point of pronotum; side margins rounded at base, constricted in front of middle, broadly rounded to rounded apices, serrate at tips; disk convex, a carina between humeri and lateral margin; surface imbricate punctate, sparsely clothed with short inconspicuous hairs.

Abdomen beneath densely punctured, pubescence short and inconspicuous, suture between the first two ventrals not well indicated at sides, unmodified in the middle. Median line of pubescence extending from prosternum to first abdominal. Prosternal lobe broadly emarginate; prosternal process not expanded back of coxal cavities. Posterior coxae with hind margin slightly sinuate, outer posterior angle not prolonged. Tibiae slender, anterior and middle pairs mucronate on inner side at apex. Tarsal claws similar on all feet, cleft, inner tooth broad, shorter than outer one and not turned inward.

Length 4.8 mm.; width 1.3 mm.

Female.—Differs from the male by the dark bronze front, lack of median ventral pubescence and tibial mucri.

Holotype male labeled Santa Cruz River Bend, Arizona, July 30, 1937, E. D. Ball, collector; *allotype* and one *paratype* labeled Acapulico, Mex., August 24, 1936, Ball and Stone; *paratype* labeled "Cuernv-Acap Road, Mexico, No. 83, August 20, 1936, Ball and Stone."

Type material in author's collection.

This species would run to *A. putillus* Say in Fisher's[5] key. However, it can be separated by the color and by the shape of the male genitalia.

Anoplium tricallosum n. sp.

Slender, elongate, brunneus throughout. Head convex, coarsely punctured on front, vertex rugose; eyes large, coarsely granulate; antennae extending slightly beyond tips of elytra when laid over the dorsal surface, scape robust, second joint about as broad as long, third joint longer than scape, fourth joint shorter than third, fifth joint longer than third, joints six to eleven inclusive gradually diminishing in length, joints five to eleven slightly flattened.

Pronotum longer than wide, widest in the middle; sides broadly rounded from base to apex; disk convex; surface densely coarsely punctured, with three raised callosities, one in center, the other two in

front, one on each side, pubescence light. Scutellum small, densely pubescent.

Elytra wider than pronotum; sides nearly parallel, apices rounded; disk convex; surface coarsely punctured, punctures larger near base, vestiture consisting of short pubescence with numerous longer hairs.

Abdomen with fine punctures and pubescence.

Length 11 mm.; width 2.9 mm.

Described from two specimens collected in Sabino Canyon near Tucson, Ariz., July 25, 1936, by the writer. *Holotype* and *paratype* in writer's collection.

This species can be separated from the other members of the genus by the callosities of the pronotum and by the absence of antennal spines. It somewhat resembles *A. duncani* Knull.

Typocerus standishi n. sp.

Female.—Form robust, resembling *T. trimaculatus* C. & K. in general appearance. Head, antennae, pronotum and elytra piceous, each elytron with four yellow transverse bands, abdomen, legs and mouthparts brunneous.

Head finely punctured, punctures larger on vertex, surface clothed with short golden pubescence; antennae reaching to apical third of elytra when laid along side of pronotum, scape stout, second joint broader than long, third joint longer than scape, fourth joint shorter than third, fifth joint longer than fourth, joints six to ten inclusive diminishing in length, last joint longer than tenth, last six joints with poriferous areas.

Pronotum convex, surface with large and small punctures, clothed with recumbent golden pubescence intermixed with long flying hairs, vestiture concealing the punctures. Scutellum triangular, clothed with golden pubescence.

Elytra wider than pronotum, widest at base, cuneiform, apices acutely emarginate, surface finely punctured, each puncture containing a recumbent hair, the color of which corresponds to the color of the background.

Ventral surface finely punctured, clothed with golden pubescence.

Length 17 mm.; width 5 mm.

Male.—Differs from the female by being smaller and less robust, stouter antennae, poriferous areas of last six segments much larger, serrations stronger.

Holotype female labeled Texas; *allotype* from Sherwood, Okla., June 27, Standish and Kaiser; *paratype* labeled Flint, Okla., June 19, 1937, Standish and Kaiser, in writer's collection. A *paratype* from Atoka, Oklahoma, June 13, 1915, H. F. Wickham, Wickham Collection, U. S. National Museum.[6]

[6]The writer is indebted to Mr. W. S. Fisher for comparison of material with the Casey types and loan of the above specimen.

I take pleasure in naming the species after Mr. John Standish.

In one of the female paratypes the elytra are black with a small yellow spot at base of each elytron and another near apex.

This species resembles *T. trimaculatus* C. & K. but can be separated by the more acute elytra apices and double type of sculpture and vestiture on pronotum. From *T. badius* Oliv. it differs in the double type of punctures on pronotum. According to Swaine and Hopping[7] the species would run to *T. acuticauda* Csy. but the two can be separated by the markings of the elytra.

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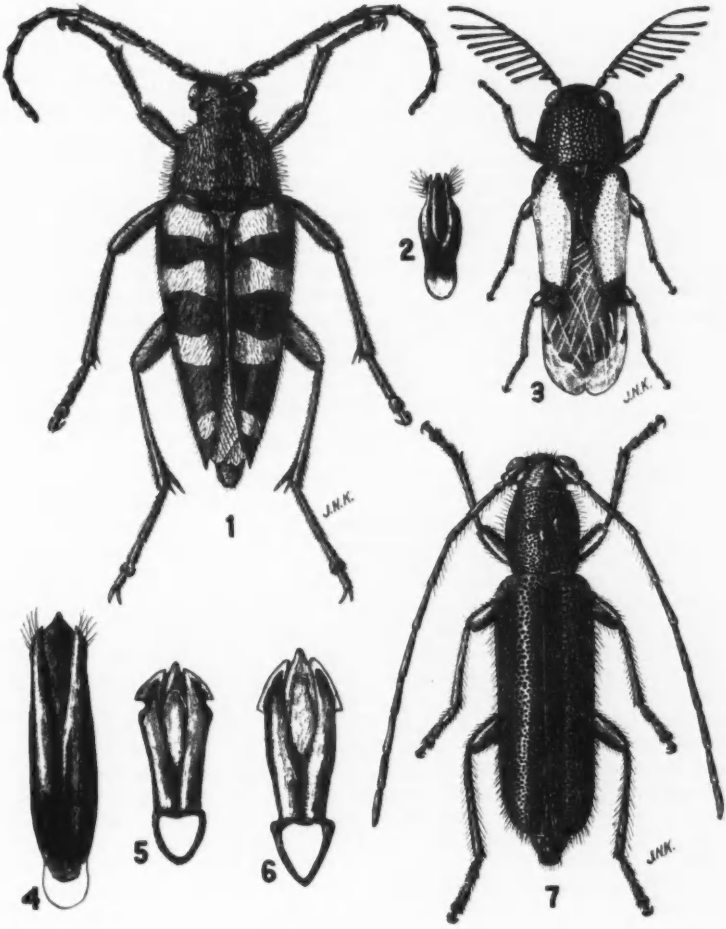
[7]J. M. Swaine & Ralph Hopping, Nat. Mus. Canada, Bul. 52, 1928.

EXPLANATION OF PLATE

Drawings made in four different magnifications

1. *Typocerus standishi* n. sp.
2. Male genitalia of *Agrilus apachei* n. sp., dorsal view.
3. *Hesperorhipis hyperbolus* n. sp.
4. Male genitalia of *Agrilus sapindi* n. sp., dorsal view.
5. Male genitalia of *Chrysobothris parapiuta* n. sp., dorsal view.
6. Male genitalia of *Chrysobothris piuta* Wick., dorsal view.
7. *Anoplium tricallosum* n. sp.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NEW THEREVIDAE (DIPTERA) FROM UTAH[1]

D. ELMO HARDY,[2]
Agricultural Experiment Station,
Logan, Utah

While working with local Therevidae, several species have come to the attention of the writer that seem to be undescribed. The material at hand consists of one new genus and two new species.

Zionea new genus

This genus is closely allied to *Nebritus* Coq. but differs in having the first antennal joint slender and the upper part of the face pilose; first segment of antennae elongate, almost as long as head and spinose; second segment very short; third segment about three-fourths as long as first, the style short and situated in a niche subapically. Antennae situated on a prominence. Occiput with dense tomentose yellow pile; the lateral margins of the mesonotum with the same type of pile. Wings dusky to brownish hyaline, the basal and marginal cells brownish fumose; cell M_3 widely open in the wing margin.

Genotype, *Zionea tanneri* new species.

Zionea tanneri new species

(Figs. 1 and 2)

Upper face thinly yellow pilose; pile around the base of the antennae longer and more dense, some darker hairs intermixed with the yellow. Pile of frons yellow. Bristles of occiput quite strong and black. Pile of occiput dense, yellow, somewhat tomentose. Pile of maxillae long and yellow. Lower part of face dense white. Lower one-third of frons shining black, the polished portion extending into the pollinose area at the middle and on the sides (fig. 1). Sides of shining area with a small silver, pollinose triangle (as seen from above, fig. 1), directly opposite the antennae. Upper two-thirds of frons yellowish gray pollinose except around ocellar prominence. Occiput shining black, vertex with two stripes of yellow pollen extending from around ocellar prominence. Face with a black shining spot on each side of oral margin, otherwise silvery pollinose.

Mesonotum with three shining brownish-black stripes longitudinally and two ochraceous vittae. The lateral margins slightly ochraceous, the ground color of the lateral margins entirely concealed (in unrubbed specimens) by dense yellow tomentum-like pile. Mesonotum with erect black hairs and a few smaller yellow hairs intermixed. Pleura, sternum,

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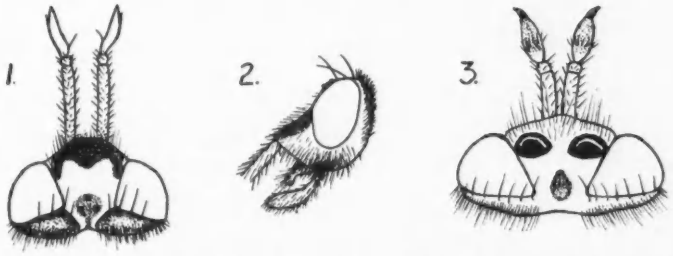
[1]Contribution from the Department of Entomology, Utah Agricultural Experiment Station.

[2]Research Assistant.

and coxae (coxae with a strong bristle on under side) gray pollinose with long grayish pile. Trochanters gray to black. Anterior femora dark gray pollinose on the basal three-fourths, yellowish apically; other femora and tibiae slightly gray to brownish pollinose basally, apical tips blackish. Metatarsi yellow basally, blackened apically; other tarsal segments black. Pile of femora silver colored and recumbent; posterior pair with two to three bristles on the under side. Tibiae with numerous spines set somewhat in whorls, pile of tibiae very short, mixed yellow and black. Pile of tarsi chiefly short, black. Scutellum shining black in ground color, somewhat grayish pollinose around the margins; pile long, grayish-yellow. Two pairs of scutellar bristles, inner pair much stronger than the outers. Stems of halteres ochraceous to grayish, knobs brownish. Wings dusky, the basal, costal, first and second marginal cells dark fumose; posterior cells dusky hyaline, somewhat smoky along the veins. Cell M_3 widely open in the wing margin.



Figs. 1 and 2. The head of *Zionea tanneri* n. sp. 1, Dorsal view. 2, Lateral view
Fig. 3. The head of *Thereva utahensis* n. sp., dorsal view.

Dorsum of abdomen brownish-black, subshining (last two tergites somewhat reddish on their distal edge), the lateral margins grayish pollinose. Pile of dorsum long, whitish, reclining anteriorly, shorter and darker posteriorly. First three to four sternites grayish pollinose, otherwise subshining. Genitalia of female somewhat reddish.

Length of specimen, 6–7 mm. Length of wing, 4.5–5 mm.

Male unknown.

Holotype, female, Zion National Park, Utah. V. M. Tanner. One *paratype*, female, same data.

Holotype is being returned to Dr. Tanner. The paratype is being deposited in the United States National Museum.

Thereva utahensis new species

(Fig. 3)

Related to **pseudoculata** Cole but differing in having no black pile on the face or around the base of the antennae.

Antennae entirely black, pilosity of the thorax darker, femora black. Abdomen chiefly shining black. Head black in ground color, face cov-

ered with silvery gray pubescence and long, dense, white pilosity; some black pile on the under side of the face near oral margin. Occiput gray pubescent, with white pile and with a row of strong bristles on the dorsal margin. Frons with two large shiny eye-like knobs; otherwise yellowish pollinose with long white pile on the lower margin (from base of knobs to antennae). Upper part of frons with sparce yellow pile and a few stronger black hairs. First and second segments of antennae black in ground color, first segment whitish pollinose with strong black bristles; third segment reddish basally, opaque black apically and with a basal fringe of hair. Style apical, about one-sixth the length of the third segment.

Thorax opaque-black in ground color; dorsum cinereous with two faint longitudinal vittae, lateral margins and scutellum dark gray pollinose; mesonotum with erect black hairs and recumbent white pile. Pleura and coxae gray pollinose with dense white pile, posterior coxae with one strong bristle on its outer edge; all coxae with several bristles dorsally. Femora black, slightly reddened apically. Tibiae red, dark brown to black apically. First three tarsal segments reddish, black apically, last two tarsal segments black. Stems of halteres pale, knobs black.

First tergite of abdomen and basal one-fourth of second tergite grayish pollinose, the medial one-half of second tergite shining black, apical portion of segment yellowish-gray pollinose; tergites three to six, lustrous black on the basal one-half to three-fourths, apical portions of each segment yellowish pollinose; segments seven and eight entirely shining black. Genitalia with a circlet of reddish spines. Pile of abdomen long and gray anteriorly, replaced by short black pile posteriorly. Sternites chiefly gray pollinose. Wings dusky yellowish hyaline with brownish clouding along the veins; cell M_3 and anal cell closed and petiolate. Stigma brown, veins brown to black.

Length of wing, 8–9 mm. Length of specimen, 10–11 mm.

Type—*Holotype, female*, North Fork, Provo Canyon, Utah, June 29, 1936, D. E. Hardy. Type deposited in the United States National Museum.

KRITISCH HISTORISCH OVERZICHT DER ACAROLOGIE, by A. C. OUDEMANS, Third Part, 1805–1850, Vol. G. General index. Pages 2736–3379. 1937. Published by E. J. BRILL, Leiden, Holland. Price 15 guilders per volume.

Above we cite the last or ninth volume of this monumental work on ticks and mites. It is a grand summary of Acarologie. On page 197, volume XXX of the Annals (1937) we gave an extended notice of the earlier volumes and have given other notices as various volumes arrived.

The present volume is the last and is a series of indices to the subject matter. There are a total of sixteen: "Idonomie, Anatomie, Histologie, Teratologie, Oekologie, Embryologie, Ontogenie, Phylogenie, Chorologie, Chronologie, Diapherologie, Oekonomie, Iatrozoologie, Onomatologie and Literatuur." The three sections of "Verbeteringen (corrections) and the sixteen indices occupy 643 pages.

It is a great work and reflects much credit on the publisher as well as on the author.—C. H. K.

SYNONYMICAL NOTES AND NEW SPECIES OF PSEUDOMETHOCA AND DASYMUTILLA (MUTILLIDAE: HYMENOPTERA)[1]

CLARENCE E. MICKEL,
University of Minnesota,
Saint Paul, Minn.

A great number of specimens of Mutillidae come to me every year from interested collectors in the United States. The new species described herein and the synonymical notes offered here are the result of studying large collections made by Professor P. W. Fattig, Emory University, Georgia, Mr. Stanley Mulaik, Edinburg, Texas, Commander C. H. Dammers, Riverside, California, and Mr. F. H. Parker, Globe, Arizona.

Genus **Pseudomethoca** Ashmead

Pseudomethoca fattigi n. sp.

Female.—Ferruginous, except the antennae, femora distally, tibiae, tarsi, broad, sinuate margin of second tergite, and third and fourth tergites, all blackish; head and thorax above clothed with moderately thick, short, recumbent, glittering, ferruginous golden pubescence; distal margin of first and second tergites with a fringe of pale, glittering hairs on the median third; third and fourth tergites clothed throughout with pale, glittering pubescence; fifth tergite with the median third pale pubescent, the lateral thirds golden pubescent; last tergite clothed laterally and anteriorly with golden pubescence; pygidial area weakly defined laterally, the pygidium glabrous, impunctate; head quadrate, slightly broader than the thorax, not toothed nor spined beneath; humeral angles prominent, strongly angulate. Length, 8.5 mm.

Head ferruginous, quadrate, the front and vertex clothed with moderately thick, short, recumbent, glittering, ferruginous, golden pubescence and sparse, erect, ferruginous hairs, the remainder of the head clothed with pale, glittering pubescence; mandibles edentate at the tip and with a strong, blunt tooth within near the tip; clypeus with a median, depressed area at the anterior margin, the area glabrous, impunctate, its posterior margin broadly arcuate; distance between the antennal tubercles equal to the transverse diameter of one of them; scape punctate and clothed with sparse, pale, glittering hairs; first segment of flagellum about one and one-fourth times as long as the second; antennal scrobes strongly carinate above; front and vertex with

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small, dense punctures throughout, the genae with the punctures larger and more or less separated; posterior margin of genae defined by a strong carina extending from the postero-lateral angles to the anterior portion of the gular carina with which it unites forming a slight tubercle; head without teeth or spines beneath or at the postero-lateral angles, the latter rounded; distance between the posterior margin of the eyes and the postero-lateral angles equal to the greatest diameter of the eyes; relative widths of head and thorax, 4.4–4.9.

Thorax entirely ferruginous, the dorsum clothed with thin, short, recumbent, glittering, ferruginous golden pubescence and sparse, erect, dark ferruginous hairs, the pleural areas only slightly pale pubescent; humeral angles prominent, strongly angulate, even slightly dentate; lateral margins of dorsum and propodeum irregularly serrate; thorax broadest slightly behind the anterior spiracles, strongly constricted at the propodeal spiracles, the relative widths at humeral angles, greatest width, propodeal spiracles and posterior face of propodeum, 3.7–3.9–2.8–3.2; dorsum of thorax with moderate, dense punctures merging into the reticulate, posterior face of propodeum; scutellar scale entirely absent; propleurae with small, close punctures and sparse, pale pubescence; mesopleura micropunctate and with pale micropubescence; a short, vertical carina on the mesopleurae extending upward from the anterior margin of the coxal cavity; metapleurae and sides of propodeum mostly glabrous, impunctate, except the ventral part of the metapleurae pale micropubescent.

Abdomen ferruginous, except a broad, sinuate band at the distal margin of the second tergite, and the third and fourth tergites entirely, black; first tergite finely punctate, the punctures sparse on most of the tergite, becoming dense towards the posterior margin, the tergite clothed with sparse, appressed, ferruginous golden pubescence and scattered, erect hairs, the latter pale laterally, dark medially, and the median third of the distal fringe of the tergite of pale, glittering hairs; second tergite with small punctures, distinct anteriorly, posteriorly and laterally, dense on the disk; second tergite clothed with sparse, recumbent, black pubescence, except towards the lateral margins and the median third of the distal fringe pale and glittering, and a pair of large, somewhat transverse spots of sparse, ferruginous golden pubescence immediately anterior to the sinuate, black band; tergites three to five finely punctate, clothed with pale, glittering pubescence, except the lateral thirds of the fifth with ferruginous golden pubescence; last tergite laterally and anteriorly with ferruginous golden pubescence; pygidial area glabrous, impunctate, weakly defined laterally by carinae; all the sternites clothed with pale, glittering pubescence; first sternite without a median, longitudinal carina; second sternite with moderate, distinct punctures, the latter sparse anteriorly, becoming close on the posterior half; sternites three to five with small, close punctures at the posterior margin; last sternite with small punctures.

Legs ferruginous, except the dorsal and distal areas of the femora, the dorsal areas of the tibiae, and the tarsi entirely, black, clothed with sparse, pale pubescence; calcaria pale.

Holotype. Female, Atlanta, Georgia, August 11, 1934 (P. W. Fattig), in University of Minnesota collection.

Paratype. Female, Yonah Mt., Georgia, June 29, 1935 (P. W. Fattig), in P. W. Fattig collection.

The large, quadrate head, constricted thorax, and large, sessile, first abdominal segment associates this species with *frigida* although the head is not dentate nor spinose beneath and the postero-lateral angles of the head are not distinctly carinate; the brilliant, ferruginous golden pubsecence of the head and thorax, the glabrous pygidium, and the form of the thorax will serve to distinguish it at once from all other species of this genus occurring in North America north of Mexico. The paratype is considerably smaller than the holotype, length 6.5 mm., and has the femora and tibiae more extensively black; in other respects it is identical with the holotype.

Pseudomethoca quadrinotata n. sp.

Female.—Entirely ferruginous, except the second tergite with a pair of small, very pale yellow spots at the anterior margin separated by a distance about twice their transverse diameter, and a pair of moderately large, whitish spots on the posterior half separated by slightly less than their transverse diameter; head quadrate, slightly broader than the thorax, the front and vertex clothed with thick, appressed, golden pubescence, the remainder of the head with appressed, pale pubescence; mandibles edentate at the tip, a small tooth within near the tip, and a large, blunt tooth within two-thirds the distance from the base to the tip; antennal tubercles widely separated; first segment of flagellum long, equal in length to segments two to four united; antennal scrobes carinate above; front, vertex and genae with small, dense, distinct punctures; genae defined posteriorly by a delicate carina; gular margin sharply angulate anteriorly, the angle elevated into a glabrous tubercle; distance between the posterior margin of the eyes and the postero-lateral angles equal to one and three-tenths times their greatest diameter; thorax subpyriform, distinctly broader than long, widest anteriorly, and constricted anterior to the propodeal spiracles; dorsum of thorax with moderate, dense, confluent punctures and clothed with sparse, black pubescence; dorsum and posterior face of propodeum punctato-reticulate, clothed with sparse, pale pubescence; scutellar scale entirely absent; pleural areas glabrous, impunctate, except the propleural area densely punctate, and all inconspicuously clothed with pale micropubescence, except the sides of propodeum almost entirely bare; lateral margins of first tergite with a large, blunt tubercle posteriorly; first tergite clothed with sparse, pale pubescence, the posterior marginal band of pale pubescence interrupted medially with black; second tergite with small, close to dense punctures, with four pale, integumental spots as described above and clothed with sparse, black pubescence, except the integumental spots with pale pubescence, and the lateral fourths of tergite

with pale pubescence, the pale pubescence of the lateral fourths and the posterior spots confluent; posterior, marginal, pubescent band of second tergite black, except the lateral sixths pale; tergites three to five finely punctured, clothed with sparse, appressed, pale pubescence and scattered, erect, black hairs; pygidial area not margined laterally, obscurely granulate, the tergite clothed for the most part with sparse, black pubescence; all the sternites with very sparse, pale pubescence, the second with moderate, separated punctures; legs including the spines entirely ferruginous, sparsely clothed with pale hairs; calcaria pale. Length, 8 mm.

Holotype.—Female, Tucson, Arizona, July 12, 1937 (D. J. and J. N. Knull), in Ohio State University collection.

Similar to *fattigi* in the pygidial area not being margined laterally, but differs greatly from *fattigi* in the long, first flagellar segment, the four pale, integumental maculations of the second tergite, the conspicuous tubercle posteriorly on the lateral margins of the first tergite, the slender mandibles with a conspicuous, inner tooth beyond the middle, and the obscurely granulate pygidium. These characters with the conspicuous yellow golden pubescence of the head greatly facilitate the recognition of *quadrinotata*.

Pseudomethoca praeclara (Blake)

1886. *Sphaerophthalma praeclara* Blake, Trans. Amer. Ent. Soc., vol. 13, p. 252. female.
1899. *Mutilla aegaeon* Fox, Trans. Amer. Ent. Soc., vol. 25, p. 229, male. (New Synonymy.)
1915. *Nomiaephagus acuum* Cockerell, Entomologist, vol. 48, p. 250, female.
1924. *Pseudomethoca praeclara* Mickel, Proc. U. S. Nat. Mus., vol. 64, Art. 15, p. 20, female.
1924. *Pseudomethoca aegaeon* Mickel, Proc. U. S. Nat. Mus., vol. 64, Art. 15, p. 45, male.
1935. *Pseudomethoca praeclara* Mickel, Trans. Amer. Ent. Soc., vol. 61, p. 394, female.

Commander C. H. Dammers, Riverside, California, sent me three males of *aegaeon* Fox which he states came to trapped females of *praeclara* Blake at San Felipe, San Diego, California. I think there can be no doubt that *aegaeon* is the male sex of *praeclara* Blake and therefore cite the above synonymy.

Pseudomethoca mulaiki n. sp.

Female.—Entirely ferruginous, except the flagellum blackish and the second tergite with a pair of tiny, obscure, yellow spots at the extreme anterior margin separated by approximately half the width of the tergite, and a pair of posterior, oblique, moderately large, ovate, pale yellow spots separated by a distance equal to their transverse

diameter; mandibles edentate at the tip and without distinct teeth within; antennal tubercles separated by a distance approximately equal to their own diameter; antennal scrobes distinctly carinate above; distance between the posterior margin of the eyes and the posterolateral angles of the head equal to the greatest diameter of the eyes; genae defined posteriorly by a distinct, sharp carina; genae not at all dentate; front, vertex and genae with moderate, dense punctures; front and vertex clothed with sparse, very dark ferruginous, almost black pubescence; genae with sparse, pale pubescence; head slightly wider than the thorax, the relative widths, 3.9–3.6; thorax as long as broad, widest at the anterior spiracles and constricted at the propodeal spiracles; humeral angles distinct but not prominent; lateral margins of mesonotal area each with a pair of short, distinct teeth; dorsum of thorax with moderately large, dense punctures becoming reticulatopunctate on the dorsum of propodeum and anterior portion of posterior face of propodeum, the remainder of the posterior face with sparse, small punctures; propleural area with moderate, distinct punctures, and with the anterior margin defined by a distinct carina; mesopleurae with a carinate ridge extending from the anterior, mesonotal tooth to a point in front of the middle coxae, the mesopleurae, metapleurae and sides of propodeum all glabrous, and the latter with a few, small, scattered punctures posteriorly; lateral margins of posterior face of propodeum denticulate; scutellar scale entirely absent; dorsum of thorax clothed with sparse, blackish pubescence; the posterior face of propodeum with sparse, long, pale hairs, and the pleural areas with very fine, short, pale pubescence; abdomen clothed with pale pubescence, and each tergite with a pale, posterior marginal fringe, except as follows: pale, posterior marginal band of first tergite interrupted medially with black, the black portion occupying the median third; second tergite clothed with sparse, black pubescence and with a black, posterior marginal fringe, except the lateral fourths of the fringe pale; lateral fourths of second tergite with sparse, pale pubescence, a transverse, arcuate band of sparse, pale pubescence posteriorly, connecting and including the posterior, pale yellow spots; the tiny, anterior, yellow spots with sparse, pale pubescence; second tergite with moderately large punctures, distinct at the sides, close posteriorly, and very dense and deep anteriorly; pygidial area distinct, finely, transversely rugose; second sternite with moderate, close punctures; legs clothed with sparse, pale pubescence; calcaria pale. Length, 10 mm.

Holotype. Female, N. E. Cameron County, Texas, off Bird Island, July 19, 1934 (S. Mulaik), in University of Minnesota collection.

Related to *oceola* (Blake), but easily recognized and distinguished from other species in the genus occurring in North America north of Mexico by the pair of posterior, pale yellow spots on the second tergite which are connected and included in a transverse, arcuate band of sparse, pale pubescence.

Genus **Dasymutilla** Ashmead

Group **Quadriguttata**

Dasymutilla mutata (Blake)

1871. *Mutilla mutata* Blake, Trans. Amer. Ent. Soc., vol. 3, p. 247, female.
1879. *Mutilla mutata* Blake, Trans. Amer. Ent. Soc., vol. 7, p. 245, female.
1886. *Sphaerophthalma mutata* Blake, Trans. Amer. Ent. Soc., vol. 13, p. 241, female.
1897. *Mutilla mutata* Dalle Torre, Cat. Hymen., vol. 8, p. 65, female.
1899. *Mutilla cypris* Fox, Trans. Amer. Ent. Soc., vol. 25, p. 240, female (in part).
1912. *Dasymutilla allardi* Rohwer, Proc. U. S. Nat. Mus., vol. 41, p. 463, female. (New synonymy.)
1916. *Dasymutilla* (*Dasymutilla*) *cypris* Bradley, Trans. Amer. Ent. Soc., vol. 42, p. 326 (in part).
1921. *Dasymutilla allardi* Banks, Ann. Ent. Soc. Amer., vol. 14, p. 25, female.
1922. *Dasymutilla allardi* Rau, Trans. Acad. Sci., St. Louis, vol. 24, p. 6, female.
1928. *Dasymutilla cypris* Mickel, Bull. 143, U. S. Nat. Mus., p. 165, female (in part).
1928. *Dasymutilla allardi* Mickel, Bull. 143, U. S. Nat. Mus., p. 166, female.

Type. Female, Maryland, in collection of American Entomological Society, Philadelphia. The type of *allardi* is in the United States National Museum.

The type of *mutata* Blake has recently been re-examined and found to be identical with the species known as *allardi* Rohwer, and not a synonym of *cypris* Blake as stated by Fox and myself. Since the name *mutata* has priority it must be re-established as the correct name for the species heretofore known as *allardi* Rohwer.

Dasymutilla mediatoria n. sp.

Female.—Ferruginous, the antennae, legs and posterior abdominal segments piceous to black; postero-lateral angles of head tuberculate; posterior margin of head distinctly convex; second tergite with a pair of anterior and a pair of posterior, pale ferruginous spots; fringe at posterior margin of first tergite mostly black, but pale laterally; fringe at posterior margin of second and third tergites mostly black, but each with a pale pubescent spot medially and also pale laterally; longitudinal striae of pygidium not extending to the posterior margin. Length, 12 mm.

Head ferruginous, the antennae and mandibles piceous to black; mandibles edentate, apparently not toothed within; clypeus with a sharp, sinuate, transverse carina posteriorly; antennal tubercles approximate; antennal scrobes not carinate above; front and vertex with large, dense, confluent punctures and clothed with sparse, recumbent, ferruginous pubescence; genae with moderate, contiguous punctures and clothed with sparse, pale, glittering pubescence; postero-lateral angles bearing an oblique, elongate, subparallel-sided, glabrous tubercle directed outward toward the eyes; posterior margin of head convex; relative widths of head and thorax, 4.5–4.9.

Thorax entirely ferruginous, the dorsum clothed with sparse, recumbent, ferruginous, coarse pubescence, the sides with sparse, pale, glittering, fine pubescence; thorax widest at anterior spiracles; relative widths of thorax at humeral angles, anterior spiracles, midway between anterior and posterior spiracles, just anterior to the latter, at posterior spiracles and at scutellar scale, 4.0–4.9–4.9–4.1–4.3–3.5; dorsum of thorax with large, dense, confluent punctures; scutellar scale present and well developed; mesonotal-scutellar ridge well developed just anterior and lateral to scutellar scale; dorsum, and posterior face of propodeum anteriorly, coarsely, confluently punctate, approaching asperate; anterior margin of propleurae carinate, the latter with large, dense, confluent punctures; mesopleurae micropunctate anteriorly, with coarse, confluent punctures posteriorly; ventral half of metapleurae with moderate, distinct punctures, the dorsal half micropunctate; sides of propodeum with moderately large, distinct, contiguous punctures.

Abdomen ferruginous, except third, fourth, fifth and last segments piceous to black; second tergite with four pale ferruginous spots, the anterior pair circular or nearly so, the posterior pair slightly transverse, subrectangular; posterior fringe of first tergite black, except lateral fifths pale; second tergite clothed with sparse, black pubescence, except the pale spots clothed with sparse, pale ferruginous pubescence, and areas of tergite laterad of pale spots with sparse, pale, glittering pubescence; posterior fringes of second and third tergites black, except each with a median, pale spot, and also the lateral sixths pale; fourth and fifth tergites clothed entirely with pale, glittering pubescence; pygidial area longitudinally striate, the striae not extending to the posterior margin, the posterior fourth of the pygidial area glabrous, unsculptured; first sternite with a median, longitudinal carina on the anterior half; second sternite with large, distinct, close punctures; sternites three to five moderately, densely punctate posteriorly; all the sternites clothed with sparse, pale, glittering pubescence, the posterior fringes of the sternites also pale.

Legs piceous to black, sparsely clothed with pale, glittering pubescence; calcaria ferruginous.

Holotype. Female, Cleveland, Georgia, June 18, 1936 (P. W. Fattig), in University of Minnesota collection.

Paratypes. Female, Cleveland, Georgia, June 18, 1936 (P. W. Fattig); female, Cleveland, Georgia, June 20, 1936 (P. W. Fattig); two females, Yonah Mt., Georgia, June 20, 1936 (P. W. Fattig); female, Yonah Mt., Georgia, June 29, 1935 (P. W. Fattig); female, Yonah Mt., Georgia, July 12, 1934 (P. W. Fattig); female, Yonah Mt., Georgia, July 15, 1934 (P. W. Fattig); female, Yonah Mt., Georgia, August 5, 1934 (P. W. Fattig); female, Head River, Georgia, June 27, 1937 (P. W. Fattig); four females, Head River, Georgia, July 13, 1937 (P. W. Fattig); female, Head River, Georgia, July 30, 1937 (P. W. Fattig); female, Head River, Georgia, August 4, 1937 (P. W.

Fattig); female, Head River, Georgia, August 5, 1936 (P. W. Fattig); female, Head River, Georgia, August 23, 1937 (H. G. Forester); two females, Cloudland, Georgia, August 4, 1937 (P. W. Fattig); female, Sitton's Gulch, Georgia, July 24, 1936 (P. W. Fattig); female, Sitton's Gulch, Georgia, August 15, 1936 (P. W. Fattig); female, Augusta, Georgia, July 2, 1937 (P. W. Fattig); female, Georgia; female, DeFuniak Springs, Florida, October 17–19; female, Lucedale, Mississippi, June 22, 1932 (H. Dietrich). Paratypes in P. W. Fattig and University of Minnesota collections.

Mediatoria is related to *mutata* Blake and *interrupta* Banks. It resembles *mutata* in general coloration and in having the posterior fourth of the pygidium glabrous and unsculptured, the striae of the pygidium not extending to the posterior margin. It differs from *mutata* in having the posterior fringes of the first three tergites mostly black, that of the first having the lateral fifths pale, and those of the second and third having the lateral sixths as well as a median spot pale. *Mutata* has the posterior fringes of the first three tergites entirely pale, except those of the second and third narrowly interrupted with black. *Interrupta* differs from *mediatoria* in having the striae of the pygidium complete to the posterior margin, and in having the posterior fringes of all the tergites usually entirely pale.

The key to the species of *Dasymutilla* (Mickel, Ann. Ent. Soc. Amer., vol. 29, pp. 31 and 32, 1936) may be modified to include *mediatoria*, and the nomenclature changed for *mutata* as follows:

43. Posterior margin of head slightly but distinctly concave, somewhat sinuate, the postero-lateral angles very prominent ..... **cypris** (Blake)
Posterior margin of head distinctly convex, the postero-lateral angles somewhat prominent 44
44. Striae of pygidium complete, reaching the posterior margin 45
Striae of pygidium not reaching the posterior margin, the posterior fourth of pygidium glabrous, unsculptured 45.5
45. Posterior fringes of first three abdominal tergites almost entirely, or entirely pale ..... **interrupta** Banks
Posterior fringes of first three abdominal tergites almost entirely black, the third tergite clothed entirely (except narrow, lateral margins pale) with black pubescence ..... **alesia** Banks
45.5. Posterior fringes of first three abdominal tergites entirely pale, except those of the second and third narrowly interrupted medially with black ..... **mutata** (Blake)
Posterior fringes of first three tergites almost entirely black, the lateral fifths of the first pale, and the lateral sixths as well as a median spot of the second and third pale ..... **mediatoria** n. sp.

Group ——?

Dasymutilla fasciventris n. sp.

Male.—Black, except the first and second abdominal segments and legs, ferruginous; front, vertex, scutellum, and fourth and fifth abdominal tergites clothed with long, thick, more or less appressed, glittering, pale pubescence; mesonotum, posterior margin of second tergite, and third and sixth tergites entirely, clothed with black pubescence; second sternite with an anterior, median, elongate pit densely filled with pale pubescence; wings fuscous, the anterior wings with a median, subhyaline area extending to the costal margin. Length, 14 mm.

Head black, clothed with pale, more or less appressed, glittering pubescence, thick on the front and vertex; mandibles slender, edentate at the tip and with two small teeth within near the tip; clypeus densely punctate, the anterior margin bidentate medially; scape strongly bicarinate beneath, finely, closely punctate and clothed with pale, glittering pubescence; first segment of flagellum slightly shorter than the second when viewed from beneath, but the two approximately equal in length when viewed from above; antennal scrobes carinate above; puncturation of front and vertex concealed by the pubescence; genae with moderate, shallow, close punctures; relative widths of head and thorax at the tegulae, 4.0–5.2.

Thorax entirely black, clothed with pale, sparse, glittering pubescence, that on the pronotum, scutellum, and anterior margin of dorsum of propodeum thick, except the mesonotum black pubescent; pronotum, mesonotum and scutellum densely punctate, the puncturation largely concealed by the pubescence; dorsum and posterior face of propodeum distinctly reticulate, the median, enclosed space of dorsum of propodeum elongate, small and inconspicuous; humeral angles rounded; propleurae with feeble, fine punctures and scattered, moderate punctures; mesopleurae with moderate to large, close but distinct punctures, the latter largest medially; metapleurae glabrous, impunctate, except ventrally with close, moderate punctures; sides of propodeum reticulate like remainder of propodeum; mesosternum with a prominent, sharp, oblique carina in front of each middle coxae; tegulae with scattered, moderate punctures and sparse, black pubescence throughout.

Abdomen black, except the first and second segments and the third sternite ferruginous, and the disk of the second tergite yellow; first and second segments, except the posterior margin of the second, and posterior fringes of sternites two to four, clothed with pale, glittering pubescence; posterior margin of second tergite, third tergite entirely, sixth tergite and pygidial tergite, all clothed with thick, black pubescence; fourth and fifth tergites with dense, more or less appressed, pale, glittering pubescence; first segment strongly nodose, the first tergite with large, close, more or less confluent punctures; disk of second tergite (yellow area) with moderate distinct, separated punctures, the latter becoming larger and closer towards the lateral and posterior margins; broad, posterior margin of second tergite black and clothed with black pubescence; puncturation of remaining tergites concealed by the pubescence; posterior margin of pygidial tergite without a fringe of

hairs; first sternite with a median, longitudinal carina on the anterior three-fourths; second sternite with large, close punctures, the latter sparser medially, and with a large, elongate pit densely filled with pale hairs situated on the mid-line anterior of the transverse median line, thus distinctly basal in position; sternites three to six with small punctures towards the posterior margin; fifth, sixth and last sternites with sparse, black pubescence.

Wings fuscous, with a subhyaline area covering cells R+1st R_1, R_5 and parts of 2nd R_1+R_2, M_4 and 1st M_2; cell 2nd R_1+R_2 obliquely truncate at the apex; cell R_4 and vein M_2 practically obsolete; vein M_3+_4 received by cell R_5 about one-third the distance from base to apex.

Legs entirely ferruginous, except the anterior tarsi entirely, and the intermediate and posterior tarsi distally, infuscated; legs clothed with pale pubescence, except the intermediate and posterior tibiae above, and the tips of the intermediate and posterior femora above with fuscous to black hairs; calcaria ferruginous.

Holotype. Male, Globe, Arizona, May 12, 1934 (F. H. Parker), in collection of University of Minnesota.

This species differs from any other male of this genus described from North America north of Mexico in the fasciate abdomen and ferruginous legs; the yellow color of the disk of the second tergite, black pubescent, posterior margin of second tergite, entire third tergite black, and the pale pubescent fourth and fifth tergites give the abdomen a trifasciate appearance, while the black mesonotum appears as a transverse black band on the thorax. The relationship of this species to other males is obscure and at the present time it cannot be placed in any of the groups established in my 1928 paper (Bull. 143, U. S. National Museum).

HANDBOOK OF MICROSCOPICAL TECHNIQUE FOR WORKERS IN ANIMAL AND PLANT TISSUES, edited by C. E. McClung; 82 illustrations, second edition, pages i-xvii and 1-698. 1937. Published by Paul B. Hoeber, Inc., (Medical book dept. of Harper and Bros.). Price $8.00.

While having had to purchase our own copy of the above work we feel that the attention of entomologists should be called to the "second edition, revised and enlarged" of "McClung."

"Among the additions are a complete, new dioxan technique for paraffin sections, directions for free hand manipulations of living material, methods for staining *boutons terminaux*, an account of the fused quartz rod method of illuminating living structure, a description of the microincineration method, a presentation of the centrifuge microscope and a description of fluorescent microscopy. The increase in the number of pages from 495 to 698 is an indication of the extent of new material added. * * * Particularly the index has been much improved."

—C. H. K.

A STUDY OF CHALCIDOID WINGS (HYMENOPTERA)

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Chalcidoid Wings, showing as they do an extreme reduction in venation for the Hymenoptera, would seem to offer little promise of producing any evidence concerning relationships with other Hymenoptera or groupings within the superfamily. It has, however, frequently been observed that the rows of macrotrichia on the wing surfaces of many insects are useful in tracing out the paths of obsolescent or obsolete veins. The chalcidoid wings are, fortunately, provided with well-marked rows of these macrotrichia and, also, fairly-definite ridges where some of the veins once lay. As there are, at the same time, various ridges in these wings which have no direct relationship to the venation, and a great many setae which do not lie on the paths of obliterated veins, it is only through the study of long series of chalcidoid wings that any conclusions at all can be drawn.

Comstock (1925) was of the opinion that in the typical chalcidoid front wing, fig. 1, the single remaining vein is the product of a partial coalescence of subcosta, radius, media, the stigma of other Hymenoptera, the radial crossvein, and the base of R_2. James (1926), who studied the wing of a species of *Harmolita*, considered costa to be wanting entirely, subcosta to be reduced to a small scale at the base of the wing, and radius and media fused to make up the only remaining vein. Hanna (1935) studied the wing and axillary sclerites of *Euchalcidia caryobori* Hanna and concluded that the scale at the wing base which had been called subcosta by James was costa instead; subcosta represented the anterior margin of the wing; radius and media fused comprised the principal vein, and cubitus and an anal vein were represented as distinct veins at the base of the wing.

An extensive search has revealed that at least one species of chalcidoid retains a relatively complete venation with most of the veins well indicated. This species is *Spilochalcis lanierii* (Guérin); its forewing is shown in fig. 2. Two aspects of this wing are at once apparent: the

venation is remarkably complete, and this venation can readily be homologized with the hypothetical type. I have followed the hypothetical hymenopterous wing proposed by Ross (1936).

The costal vein represents the anterior margin of the wing from the wing base to the beginning of the marginal vein. There is a thickening at the base of C; this probably represents the humeral crossvein. This crossvein can be seen clearly in the wing of *Leucospis affinis* Say, fig. 5. This thickening at the base of costa is the scale found in this part of the wing in most other Chalcidoidea. Immediately posterior to C is the strong submarginal vein; this is a product of the fusion of Sc and R, as is true in other Hymenoptera. Near the point where C ends, there can be seen a slight break in the submarginal vein. This undoubtedly represents the end of Sc; this supposition is strengthened by the fact that this break does not extend entirely across the vein, but only across the anterior part. The marginal vein and postmarginal vein represent R_1. The stigmal vein is the second radial crossvein, thus agreeing with most other higher Hymenoptera, which retain this crossvein as a strong vein. In practically all chalcids, another vein can be seen to diverge from the apex of the stigmal vein. This probably represents a r-m crossvein, despite the fact that it generally lies parallel to the longitudinal axis of the wing. In some species this vein can be seen to extend toward M, as in fig. 6. The submarginal vein (Sc plus R) forms, with the bases of M plus Cu_1, M, and Rs, a well-marked triangle at the wing base, as in almost all Hymneoptera. Rs diverges from R and joins M to fuse with it for a short distance and then diverge again as an independent vein. Radial sector runs toward the anterior wing margin, intersecting the end of the stigmal vein (2 r) and then ending at the wing margin near the end of the postmarginal vein. Media, after diverging from Rs, continues in a relatively simple, straight path to the wing margin. Cu_1 runs nearly straight from the point of divergence of M to the margin of the wing. The most of this vein is actually Cu_{1a}, but in most chalcids all indications of Cu_{1b} have been lost. Posterior to Cu_1 there is invariably a strong concavity. This represents Cu_2. Posterior to Cu_2 is a single poorly-defined anal vein. Almost all chalcids also retain a strong concavity in the wing between M and Cu_1. This may represent a long-since lost branch of media.

The wing of *Leucospis*, fig. 5, is, in many respects, the most generalized to be found in the superfamily. Both branches of Cu_1 are clearly indicated and the cu-a crossvein can be seen. Despite the fact that a fold runs across the path of M, this vein is fairly well preserved back to the piont of its divergence from Rs; two m-cu crossveins are also fairly-well represented, as in a number of other Hymenoptera, but no other chalcids. It can be seen that M and Rs are fused for but a short distance in the wing of *Leucospis*. This is the condition found in all other Chalcidoidea except the Chalcididae (*s. s.*), where Rs and M are fused for a considerable distance, as in figs. 2 and 4.

The study of a number of chalcid wings shows that a gradual movement of the venation inward and anteriorly has occurred. A somewhat intermediate step in this direction is found in most Encyrtidae, fig. 8. M has moved far forward and R_1 has been shortened greatly. The shift

in the apex of Rs toward the base now causes this vein to assume the direction of a crossvein. The ultimate in this shifting of the veins toward the anterior base is to be seen in the Mymaridae, fig. 10. Here practically all the recognizable veins have been crowded almost to the base and the distal part of the wing contains only a few vague wrinkles whose homologies cannot be determined with certainty.

In *Elasmus*, fig. 9, the wing is curiously lengthened in the area of the marginal vein, and M has been drawn back sharply toward Cu_1. In a very large percentage of chalcids M drops out entirely distal to the point of divergence from Rs. In the Eulophidae, however, M may either be drawn back parallel with Cu_1 for most of its length or be lost entirely, as in fig. 7. In *Leptophoenus* (*Pelecinella*), M is retained as a strongly-sclerotized vein throughout practically its entire length. This condition has been found nowhere else in the superfamily.

The members of the tribe Haltichellini of the Chalcididae exhibit a number of quite primitive morphological characters, and their wings are the most difficult to explain of any wings in the superfamily. In addition to the usual veins there is an accessory radial vein apparently springing from the r-m crossvein, fig. 4. This vein might conceivably represent the furrow of a long-since lost additional branch of radius. Throughout the Hymenoptera are to be found wings with a well-defined furrow in this area. In the chalcid wing, when practically all of the venation has been reduced to at most vague furrows or ridges, there is practically no way of distinguishing the paths of furrows which would be disregarded in other Hymenoptera, and furrows or ridges which actually represent important veins. By comparison with the other Chalcididae, however, it can be seen that this accessory radial vein is in addition to those always present elsewhere. It is, therefore, possible to assume that this vein is homologous with the furrow found in other hymenopterous wings in this area. Also in the wing of *Antrocephalus*, fig. 4, there is a well-marked furrow extending from Rs plus M to the wing margin. This may be homologous with the furrows found in the corresponding area of the wings of other Hymenoptera. If some name must be given to this, it will be necessary to consider it a posterior branch of media.

SUMMARY

In a typical chalcidoid wing, fig. 1, the submarginal vein represents Sc plus R, the marginal and postmarginal veins R_1, and the stigmal vein is the second radial crossvein. The rest of the veins have been lost, but their paths can still be traced in many forms. When the wing is reconstructed, as in fig. 2, it can readily be homologized with the hypothetical type. This fact indicates that the chalcids diverged from the Apocrita stem before any very great specialization in the wings had occurred; the subsequent independent specialization within the Chalcidoidea has led to a gradual loss of all the principal veins except those at the anterior margin.

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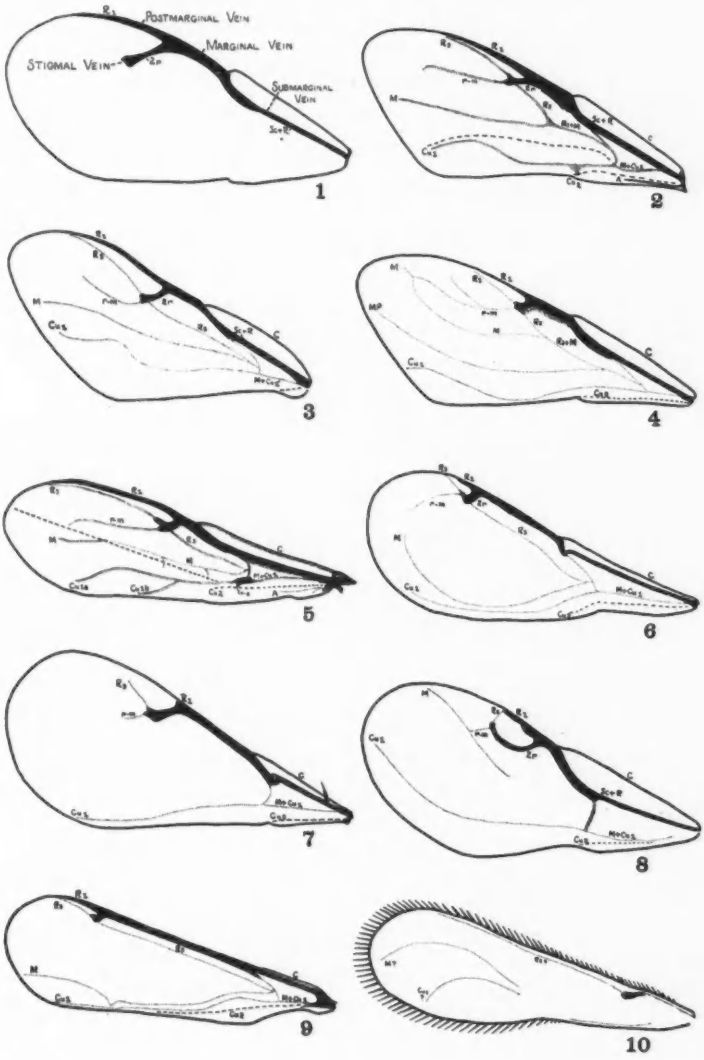
EXPLANATION OF PLATE

Forewings of Chalcidoidea:

Fig. 1. *Pteromalus puparum* (Linn.) (Pteromalidae).
Fig. 2. *Spilochalcis lanierii* (Guérin) (Chalcididae).
Fig. 3. *Euperilampus triangularis* (Say) (Perilampidae).
Fig. 4. *Antrocephalus* sp. (Chalcididae).
Fig. 5. *Leucospis affinis* Say (Leucospidae).
Fig. 6. *Spalangia muscidarum* Richardson (Pteromalidae).
Fig. 7. *Tetrastichus asparagi* Crawford (Eulophidae).
Fig. 8. *Eucomys fusca* (Howard) (Encyrtidae).
Fig. 9. *Elasmus meteori* Ashmead (Elasmidae).
Fig. 10. *Polynema striaticorne* Girault (Mymaridae).


POSTMARGINAL VEIN
MARGINAL VEIN
STIGMAL VEIN
SUBMARGINAL VEIN
1
2
3
4
5
6
7
8
9
10

THE APHID GENUS MICROSIPHUM IN UTAH AND IDAHO[1]

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The genus *Microsiphum* (Cholodkovski, Zool. Anz., 32: 687, 1908) may be characterized as: Frontal tubercles moderately developed but not exceeding vertex; secondary sensoria circular; cornicles not longer than broad at base and truncate or short-cylindrical; cauda broader than long, conical with narrowed tip; fore wings with mediae twice-forked; hairs blunt to slightly fan-shaped.

KEY TO APTERA

A. Body bearing blunt to fan-shaped hairs ..... **oregonensis**
AA. Body not bearing fan-shaped hairs.
B. Unguis more than 5-times base of VI ..... **artemisiae**
BB. Unguis less than 5-times base of VI ..... **acophorum** n. sp.

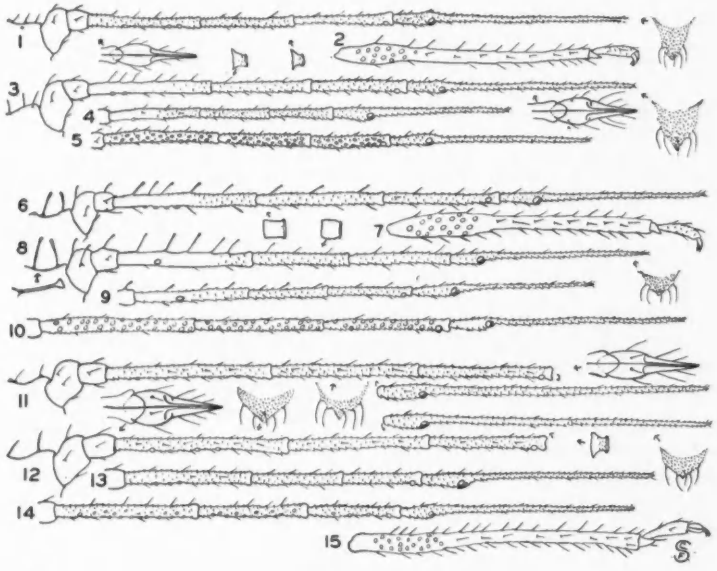
Microsiphum acophorum n. sp.

Apterous vivipara. Color shiny brownish-black to black, often with a distinct brown patch over the abdomen of cleared specimens; body 1.02 to 1.6 mm. long and bearing pointed to blunt hairs 0.027 to 0.045 mm.; hairs on vertex 0.038 to 0.045; hairs on antennal III, 0.024 to 0.034; antennae dark beyond basal two-thirds of IV and 1.17 to 1.72 mm. long; antennal III, 0.22 to 0.35 mm. long and bearing 1 to 4 sensoria; IV, 0.17 to 0.32; V, 0.17 to 0.28; VI, 0.09 to 0.11+0.35 to 0.50; rostrum attaining first abdominal segment; rostral IV+V, 0.125 to 0.14; hind tibiae 0.59 to 0.98; hind tarsi 0.125 to 0.14; cornicles 0.041 to 0.05; cauda 0.07 to 0.10 mm. long.

Collections: On *Artemisia tridentata* at Altonah, September 3, 1937 (Knowlton; F. C. Harmston); Amazon Mine, Logan Canyon, August 30, 1937, (Smith); Boneta, September 3, 1937 (Knowlton; Harmston); Brigham Canyon, August 10, 1927 (Knowlton); Hansel Mountains, May 19, 1930 (Knowlton); Hyrum, August 17, 1927 (Knowlton); Boys' Camp, Logan Canyon, August 24, 1934 (Knowlton); Logan, August 20, 1927 (Knowlton) and August 2, 1936 (Knowlton; Harmston); Mill-

[1]Contribution from the Department of Entomology, Utah Agricultural Experiment station.
Authorized for publication by the Director.
[2]Research Assistant and Associate Entomologist, respectively.

ville, August 17, 1927 (Knowlton) and North Logan, August 10, 1926 (Knowlton); Providence, August 17, 1927 (Knowlton) and 15 miles west of Woodruff, August 30, 1937 (Knowlton; Smith) in Utah. In Idaho at Bear River Narrows, August 29, 1936 (Smith); Riverdale, July 24, 1936 (Smith); and Whitney, July 9, 1937 (C. F. Smith; C. K. Smith; F. C. Harmston). Specimens collected on *Artemisia longifolia* at Chimney Rock, Colorado, September 11, 1922, by Professor M. A. Palmer, are fairly typical of this species.



Figs. 1–5. *Microsiphum acophorum* n. sp. 1. Alate. 3. Aptera. 2 and 4. Oviparous female. 5. Alate male.
Figs. 6–10. *M. oregonensis* Wilson. 6. Alate. 7 and 9. Oviparous female. 8. Aptera. 10. Alate male.
Figs. 11–15. *M. artemisiae* (Gillette). 11. Alate. 12. Aptera. 13 and 15. Oviparous female. 14. Apterous male.

Alate vivipara. Color black; body 1.25 to 1.41 mm. long and bearing hairs 0.025 to 0.032 mm. long on the abdomen; hairs on vertex 0.026 to 0.032; hairs on antennal III, 0.024 to 0.031; antennae dusky to dark and 1.38 to 1.5 mm. long; antennal III, 0.28 to 0.32 mm. and bearing 5 to 6 sensoria; IV, 0.23 to 0.28; V, 0.23 to 0.28; VI, 0.09 to 0.11+0.41 to 0.5; rostrum attaining first abdominal segment; rostral IV+V, 0.125; hind tibiae 0.78 to 0.84; hind tarsi 0.14; cornicles 0.04; cauda 0.1 mm. long.

Collections: On *Artemisia tridentata* at Whitney, Idaho, July 9, 1937 (C. F. Smith; C. K. Smith; F. C. Harmston).

Apterous ovipara. Color shiny brownish-black; body 1.27 to 1.41 mm. long and bearing pointed hairs 0.038 mm. long on the abdomen; vertex hairs 0.038; hairs on antennal III, 0.031; antennae 1.12 to 1.5; antennal III, 0.23 to 0.32 mm. long and bearing 0 or 1 sensorium; IV, 0.16 to 0.28; V, 0.16 to 0.26; VI, 0.1 to 0.11+0.33 to 0.45; rostral IV+V, 0.125; hind tibiae 0.53 to 0.80; hind tarsi 0.11 to 0.14; cornicles 0.041 to 0.047; cauda 0.08 mm. long.

Alate male. Color greenish-brown; body 1.02 to 1.6 mm. long and bearing pointed hairs 0.013 mm. long on the abdomen; vertex hairs 0.024; hairs on antennal III, 0.02 to 0.027; antennae 1.4 to 2.1; antennal III, 0.3 to 0.45 mm. long and bearing 20 to 28 sensoria; IV, 0.25 to 0.4 mm. long and bearing 15 to 29 sensoria; V, 0.157 to 0.26 mm. and bearing 10 to 20 sensoria; VI, 0.10 to 0.12+0.35 to 0.59; rostral IV+V, 0.11 to 0.12; hind tibiae 0.7 to 1.0; hind tarsi 0.11 to 0.12; cornicles 0.041; cauda 0.049 mm. long.

Collections: Alate males and apterous ovipara on *Artemisia tridentata* at Logan, Utah, October 7–9, 1927, (Knowlton). Also on *Artemisia longifolia* at Chimney Rock, Colorado, September 11, 1922 (M. A. Palmer).

Taxonomy: Microsiphum acophorum n. sp. differs from *M. oregonensis* Wilson in having pointed hairs on vertex and abdomen; hind tibiae of apterous ovipara bearing fewer sensoria; and in having fewer sensoria on antennal V of alate males. From *M. artemisiae* (Gill.) it differs in having unguis less than 5-times base; hind tibiae of oviparous female being more distinctly swollen and bearing fewer sensoria; and males being alate and bearing more sensoria on antennal V.

Types: Type slide in the U. S. National Museum. *Paratypes* in the collections of the writers.

Microsiphum artemisiae (Gillette)

Gillette, Ent. News, 22: 440, 1911. (*Chaitophorus.*)

Apterous vivipara. Color shiny chocolate brown; body 1.25 to 1.6 mm. long and bearing hairs 0.034 to 0.056 mm. long; hairs on the vertex 0.049 to 0.065; hairs on antennal III, 0.013 to 0.038; antennae dark beyond middle of III; antennal III, 0.35 to 0.45 mm. long and bearing 3 to 6 sensoria; antennal IV, 0.28 to 0.36; V, 0.23 to 0.31; VI, 0.10 to 0.11+0.55 to 0.70; rostrum attaining 1st abdominal segment; rostral IV+V, 0.157; hind tibiae 0.83 to 0.98; hind tarsi 0.15 to 0.16; cornicles 0.03 to 0.04; cauda 0.069 mm. long.

Collections: On *Artemisia vulgaris* at Avon, Blacksmith Fork Canyon, Brigham, Clinton, College Ward, Collinston, Cornish, Fielding, Honeyville, Hyde Park, Hyrum, Logan, Mouth Logan

Canyon, North Logan, Mapleton, Mendon, Ogden, Paradise, Roy, Sunset, Tremonton, Wellsville, in Utah. Collections in Idaho at Bear River Narrows, Immigration Canyon, Mink Creek, Preston and Riverdale.

Alate vivipara. Color brown; body 2.0 to 2.4 mm. long and bearing hairs 0.045 to 0.05 mm.; vertex hairs 0.027 to 0.038; hairs on antennal III, 0.017 to 0.027; antennae 2.22 to 2.26; antennal III, 0.4 to 0.5 mm. long and bearing 6 to 8 sensoria; IV, 0.37 to 0.41; V, 0.32 to 0.37; VI, 0.11 to 0.125+0.70 to 0.75; rostrum attaining third coxae; rostral IV+V, 0.145 to 0.157; hind tibiae 1 to 1.09; hind tarsi 0.157; cornicles 0.034; cauda 0.09 to 0.096 mm. long.

Collections: On *Artemisia vulgaris* at Brigham, Clinton, Hyde Park, in Utah. In Idaho at Riverdale.

Apterous ovipara. Color brown; body 1.41 to 1.75 mm. long and bearing hairs 0.038 to 0.045 mm. long on abdomen; vertex hairs 0.045 to 0.049; hairs on antennal III, 0.02 to 0.038; antennae 1.5 to 1.64; antennal III, 0.34 to 0.39 and bearing 3 to 4 sensoria; IV, 0.23 to 0.28; V, 0.19 to 0.23; VI, 0.094 to 0.11+0.45 to 0.52; rostrum attaining 1st abdominal segment; rostral IV+V, 0.14; hind tibiae 0.69 to 0.78; hind tarsi 0.125 to 0.14; cornicles 0.034; cauda 0.069 to 0.08 mm. long.

Apterous male. Body 1.50 to 1.62 mm. long and bearing pointed hairs on body 0.038 mm. long; vertex hairs 0.041; hairs on antennal III, 0.02 to 0.03; antennae 1.5 to 1.62; antennal III, 0.33 to 0.4 mm. long and bearing 14 to 22 sensoria; IV, 0.25 to 0.30 mm. and bearing approximately 12 sensoria; antennal V, 0.2 to 0.25 mm. and bearing 2 to 4 sensoria; rostral IV+V, 0.12 to 0.13; hind tibiae 0.69; hind tarsi 0.14; cornicles 0.034; cauda 0.042 to 0.06 mm. long.

Collections: Males and oviparous females on *Artemisia vulgaris* at Brigham, October 11, 1927, and Logan, October 14, 16 and 17, 1927.

Taxonomy: This species differs from *Microsiphum oregonensis* in body hairs being shorter and more pointed; unguis being 5 or more times base of VI; hind tibiae being less swollen; and antennal V of males bearing fewer sensoria.

Microsiphum oregonensis Wilson

Wilson, Trans. Amer. Ent. Soc., 41: 91, 1915.

Apterous vivipara. Color shiny reddish-brown; body 1.06 to 1.57 mm. long and bearing numerous, long, apically widened hairs 0.06 to 0.07 mm. long on the abdomen; vertex hairs 0.04 to 0.054; hairs on antennal III, 0.034 to 0.042; antennae 1.2 to 1.65; antennal III, 0.23 to 0.35 mm. and bearing 1 sensorium; IV, 0.17 to 0.29; V, 0.19 to 0.31; VI, 0.094 to 0.11+0.37 to 0.52; rostrum attaining 3d coxae; rostral IV+V, needle-like and 0.125; hind tibiae 0.58 to 0.9; hind tarsi 0.125 to 0.14; cornicles 0.05 to 0.06; cauda 0.05 to 0.07 mm. long.

Alate vivipara. Color brown; body 1.17 to 1.41 mm. long and bearing hairs on abdomen 0.041 to 0.056 mm.; vertex hairs blunt to widened slightly apically and 0.034 to 0.038; hairs on antennal III, 0.031 to 0.045; antennae 1.68 to 1.72; antennal III, 0.38 to 0.45 mm. long and bearing 3 to 8 sensoria; IV, 0.31 to 0.37; mm. V, 0.29 to 0.36; VI, 0.10 to 0.11+0.37 to 0.47; rostral IV+V, 0.12; hind tibiae 0.97 to 1.04; hind tarsi 0.12 to 0.14; cornicles 0.04 to 0.053; cauda 0.07 mm. long.

Apterous ovipara. Color shiny black to blackish-brown; body 1.25 to 1.41 mm. long and bearing apically widened hairs 0.065 mm. long on the abdomen; vertex hairs 0.05 to 0.065; hairs on antennal III, 0.034 to 0.04; antennae 1.25 to 1.35; antennal III, 0.29 mm. long and bearing 1 or 2 sensoria; IV, 0.21; V, 0.22 to 0.28; VI, 0.094 to 0.11+0.33 to 0.37; rostral IV+V, 0.11 to 0.125; hind tibiae 0.7 to 0.77; hind tarsi 0.12; cornicles 0.05 to 0.06.

Alate male. Color brownish-black; body 1.0 to 1.31 mm. long and bearing blunt hairs 0.027 to 0.034 mm. long on the abdomen; vertex hairs 0.028; hairs on antennal III, 0.024 to 0.031; antennae 1.72 to 1.9; antennal III, 0.39 to 0.45 mm. long and bearing 30 to 40 sensoria; IV, 0.31 to 0.37 mm. and bearing 25 to 27 sensoria; V, 0.29 to 0.37 mm. long and bearing 19 to 25 sensoria; VI, 0.11 to 0.14+0.47 to 0.55; rostral IV+V, 0.11 to 0.125; hind tibiae 0.84 to 0.91; hind tarsi 0.125 to 0.14; cornicles 0.04; cauda 0.06 mm. long.

Collections: On *Artemisia tridentata* at Brigham Canyon; Cove Fort; Granite; Honeyville; Hooper; Kanab; Logan, Snowville, and Woodruff in Utah. In Idaho at Castle Ford and Riverdale.

Taxonomy: This species is peculiar because of the long, flattened to fan-shaped hairs which occur on the vertex and dorsum of abdomen.

DESCRIPTIONS OF NEARCTIC CADDIS FLIES, by HERBERT H. Ross, pp. i-iii and 1-183, text figs. 123, 1 plate. 1937. Published as Article 4, vol. 21, of the Bulletin of the ILLINOIS NATURAL HISTORY SURVEY, Natural History Bldg., University of Illinois, Urbana, Illinois.

Though in bulletin form, we wish to call attention to this as part of a survey of the Trichopterous fauna of the waters of Illinois. This survey was initiated under the supervision of Professor Cornelius Betten, of Cornell University, during the summer of 1931, who acquainted the Survey staff with the characters used in identifying caddis-flies and in so far as possible with the names of common species. Since that summer Doctor Herbert H. Ross of the Survey has been in charge of the work. Early it was seen that a major taxonomic problem had been encountered. Described species from across the continent had to be positively checked off. This meant a careful study of the Hagen and Banks types in the Museum of Comparative Zoology at Harvard, and the collection and study of many species outside the boundaries of the State of Illinois.

Caddis-flies are collected at night while attracted to a neon light enclosed in a glass case. They are taken by placing the mouth of an alcohol-filled vial over them as they dance on the glass of the neon light case. Later, species are sorted in the laboratory. Specific descriptions are based largely on the characters of male genitalia. In each of the species described in the present bulletin the male genitalia are figured. The eventual completion of the report on the caddis-flies of Illinois will give us the first general view of the Trichoptera of one of the upper Mississippi Valley states.—C. H. K.

COCOON FORMATION IN ENDOPARASITIC CHALCIDOIDS[1]

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In the course of routine investigations of the biology of certain parasites of *Saissetia oleae* (Bern.) introduced into California from Africa by the University of California Citrus Experiment Station in 1937, it was observed that each of the full-fed larvae of the endoparasitic species was enclosed in a cocoon[3] while still immersed in the body fluids of its host. Although the cocoons did not appear to be constructed in the same manner as those of ectoparasites, they seemed to be of the same kind of material and to serve the same purpose.

The parasites studied included several endoparasitic species of aphelinids and encyrtids and an ectoparasitic miscogasterid. The ectoparasite (*Mesopeltis* sp.) spun a typical hymenopterous cocoon.

EARLIER RECORDS

It has often been stated that chalcidoid pupae generally are naked, i. e., unprotected by a larval envelope. Certain exceptions to this rule, however, have been recorded. Nees ab Esenbeck (1834) observed cocoon formation by *Euplectrus bicolor* in 1809. Schwarz (1881) noted that *Euplectrus comstocki* attached the depleted skin of its host, *Alabama argillacea*, to the host plant by means of silken threads, forming an incomplete cocoon. Likewise Smith and Compere (1928) observed that the solitary larva of *Scutellista cyanea* after feeding on the eggs of black scale (*Saissetia oleae*) pupated beneath the scale after attaching it to the host plant by strands of silk. A gregarious parasite, *Enargopelte ovivora*, similar in feeding habit to *Scutellista*, constructs a complete cocoon beneath the body of its host (Ishii, 1928).

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[1]Paper number 374, University of California Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside.

[2]Assistant Entomologist in the Citrus Experiment Station.

[3]Cocoon: a covering, composed partly or wholly of silk or other viscid fiber, spun or constructed by many larvae as a protection to the pupa. (From *Explanation of Terms Used in Entomology* by John B. Smith.)

It is evident that there are at least three genera of ectoparasitic chalcidoids that have the cocoon forming habit in some degree. Such a habit, however, has been considered entirely wanting in the endoparasitic species. Nevertheless certain related phenomena have been observed by several investigators.

Howard (1891) states that the larvae of several encyrtids (*Copidosoma*, *Bothriothorax*, etc.), when about to pupate formed oval cells within their hosts. A thin-skinned host appeared inflated when filled with such cells. He remarked that, "The nature of this cocoon-like cell and the method by which it is produced are unknown. Its structure shows it not to be silk, nor yet the last larval skin of the parasite and whether it is an adventitious tissue of the host larvae or a secretion of the parasite, or is explicable upon other grounds, I cannot say." An explanation of the nature and formation of such a cell appeared the following year. Bugnion (1892) observed that the gregarious mature larvae of *Ageniaspis fuscicollis* secreted a viscous liquid about themselves which soon hardened to form rigid partitions supporting the host's skin. Each larva occupied a "loge" in which it pupated. The partitions or walls of these loges were amorphous, brittle, and, to a large extent, insoluble in caustic potash.

Marchal (1904), however, in his classical paper on polyembryony, disagreed with Bugnion's conclusions and stated that the cuticle of each larva formed a puparium comparable to those of the Diptera.

Embleton (1904) observed that the last larval instar and pupa of *Encyrtus infelix* while immersed in the body fluids of its host (*Saissetia hemisphaerica*) is enveloped by ". . . . a well defined and ample membranous sheath . . . " As to the nature and origin of the "sheath" she was quite in doubt. A similar phenomenon is recorded by Timberlake (1913) in the case of *Coccophagus scutellaris*, a parasite of *Coccus hesperidum*. This parasite likewise pupates *in situ* while the host is still alive. He states that this remarkable habit is made possible because of a "protecting shroud" filled with air. It appeared to him that this covering consisted of the exuvia last discarded. Imms (1918) found that the pupae of *Metaphycus punctipes* not infrequently were enclosed in a membranous cocoon-like structure which appeared to be the dried remains of the "sheath" within the dead host. Smith and Compere (1928) observed that the gregarious pupae of *Metaphycus lounsburyi* occupied thin-walled

cells within their host (*Saissetia oleae*) and that the cell walls contained bits of host tracheae. Myers (1930) noted a "strange hymenopterous puparium" surrounding the pupa of *Carabunia myersi*. The last stage larva of an egg parasite, *Ooencyrtus johnsoni*, was observed by Maple (1937) to be partly surrounded by a thin, transparent membrane. Recently an examination of the eggs of *Prenes nero* Felder, parasitized by an undescribed species of *Ooencyrtus*, showed that each egg contained three pupae, each within a cell of thin, transparent material. The portion adjacent to the egg shell was melanized. In this connection it is interesting to note that Przibram (1924) found that the cocoons of certain sawflies consist, in part, of dioxyphenylalanine ("dopa") which produces melanin by oxidation in a moist alkaline medium. The characteristic black appearance of certain parasitized hosts (scales, aphids, etc.), may be due to a similar phenomenon. Clausen (1932) states that the dorsal portion of the envelope surrounding *Encyrtus infidus* becomes dark even when immersed in the host's fluids.

THE COCOON MATERIAL

The observations mentioned above were incidental, in nearly every case, to a general biological investigation. Superficially there is little resemblance between the typical cocoon as in *Euplectrus* and the "sheath" of the endoparasitic *Encyrtus*. Observations by the writer, however, indicate rather definitely that cocoon and "sheath" are essentially the same in nature and origin. Earlier observations by others support this contention.

Thomsen (1927) observed that the hind gut of *Euplectrus* was filled with a nearly homogeneous substance which stained with eosin. This substance apparently was web material. Imms (1918) found the "sheath" of *Metaphycus* to be eosinophilous.

Thomsen observed "liquid threads" issuing from the anus of *Euplectrus*. *Mesopeltis* likewise produces a thread which is strong enough to suspend the entire weight of the larva. Before exposure to air it is very adhesive and is insoluble in water. This fact suggested a logical method to account for "sheath" formation by endoparasitic larvae when surrounded by the fluids of the host. The excretion of a fluid, waxy substance having an affinity for the smooth, hydrofugic surface of the parasite larva would flow over its body and under pressure of

the host's fluids form a thin, tightly fitting, transparent membrane. Thorpe (1936), who has made an intensive study of "sheath" formation in *Encyrtus infelix* states that the sheath is waxy in nature, quite structureless, lacking in chitin, and appears to contain a great deal of "cuticulin-like" substance. At first incomplete, it " . . . soon spreads to form an entire envelope and rapidly becomes tough . . . " Portions of the host's tracheae are incorporated in it. After the cocoon is formed the full-fed larva becomes somewhat smaller, openings occur in the tracheal attachments, and outside air is pulled in. In many species the endoparasitic larva has the same freedom of movement within its membraneous cocoon as the ectoparasite within its silken one.

The belief that the "sheath" was made up in whole or in part by the larval exuvia was definitely disproved by Thorpe, since he found that the last larval skin was always discarded within the "sheath." This fact provides an explanation of how Marchal arrived at his opinion concerning the nature of the envelope surrounding the newly formed pupa of *Ageniaspis fuscicollis*. It is evident that he studied the material *after* the final larval ecdysis. In his Canada balsam preparations the chitinized buccal armature of the cast skin likely would appear to be part of the wall of the cell containing it.

The theory advanced by Thorpe to account for the formation of the "sheath" in *Encyrtus infelix* appears inapplicable. He attempted to show that the "sheath" was built up by means of the host's phagocytic blood cells and proliferated tracheae. He thought it likely that the phagocytes responded to a stimulus provided by the secretions of the segmental dermal glands of the last larval instars. This is disproved by the fact that such glands do not occur in larvae that produce similar "sheaths" as in *Coccophagus*, *Metaphycus*, etc. Thorpe also found that the thickening and toughening of the "sheath" continued up to the time the parasite pupates. If this structure resulted from some host activity its formation would not cease necessarily with the metamorphosis of the parasite.

FUNCTION OF THE COCOON

In the case of ectoparasites the host cocoon serves as a protection during the resting or metamorphic period of the life cycle. The cocoons containing *Microplectron fuscipennis*, for example, prevent the dessication of larva and pupa (Ullyett,

1936). The dead hosts of endoparasites may serve this purpose. However, the larvae of many species become mature and full-fed before the host dies. The last stage larva must, then, either leave the body of its host or provide an adequate supply of oxygen and a means of protection from the host's fluids. Full-fed endoparasitic ichneumonoid larvae that have not consumed all of their hosts' tissues emerge therefrom, whereas chalcidoid larvae remain within, as a rule. Many species of chalcidoids, therefore, construct in live hosts a "sheath" or cocoon of a peculiar type. In some of these species (*Coccophagus rusti* Comp.) the host dies and its fluids dry up, disrupting the delicate cocoon before the parasite pupates. It is because of this fact that the formation of a protective covering in most endoparasitic chalcidoids has been overlooked. In other species (*C. scutellaris*) the parasite pupates within its cocoon and emerges as an adult from the living host.

The means by which such larvae obtain their air supply is of considerable interest. When the cocoon is formed within live hosts, portions of the host's tracheae become embedded in it. Usually little uniformity is apparent in such attachments. However, in certain species, the larvae of which possess a reduced number of spiracles, the points of attachment are quite uniform in number and position. In *Encyrtus*, according to Clausen (1932), several tracheae are usually attached in the immediate vicinity of each of the four spiracles of the last instar larvae. At these points the tracheae lie in short, trough-like depressions. The membrane at the points of union is infuscated. Embleton observed the same phenomenon but thought that the tracheae were outgrowths of the larvae. Clausen described the tracheal connection as follows: "In several instances the tracheae were traced directly from the host spiracle to the point of fusion . . . and then onwards to the viscera of the host. Occasional individuals revealed tracheae which fused at two successive spiracular areas. . . In several cases the same trachea was noted to have fused with the spiracular areas of two larvae lying close together. Where a large number of individuals are crowded into a single host the tracheae connecting with the spiracular areas are all usually from the same host spiracle. Beyond the points of fusion there seems to be a greater branching and development of the tracheae than is normally the case, this possibly having been induced by the increased demands made upon them. . . . The tendency to

fusion . . . is not restricted to that with the host tracheal system alone." Clausen noted several instances of fusion with discarded spiracular stalks of other individuals and one instance of fusion with the intestine of the host at one end of the larva and host tracheae at the other.

The cocoon membrane apparently is more adhesive in the vicinity of the spiracles of the parasite. Clausen states that the period in the development of the parasitic larva at which the respiratory connection is made is not constant. . . . He noted in *Encyrtus* that occasionally fusion occurred while the larva still possessed functional caudal spiracles. Thorpe found traces of an extremely thin membrane partially surrounding the late third or early fourth instar larvae. He states, however, that in the early stages of sheath formation there are no signs of tracheal attachments, although fine tracheal branches may be seen running over the membrane here and there appearing to coalesce with it. In other species, as in *Coccophagus*, the cocoon membrane is not formed until the larva is full-fed.

It seems evident that, as a rule, tracheal attachments are made when the cocoon is completely formed and while it tightly fits the larval body except at the spiracular cups. In *Carabunia myersi* the tracheal attachments occur very gradually and one by one but without regularity (Myers, 1930). The apposition of the tracheal attachments to the larval spiracles in most species may not be observed because of the changing position of the larva.

ORGANS INVOLVED IN COCOON FORMATION

In most cocoon forming Hymenoptera the cocoon material is elaborated in a pair of labial glands and discharged through a common duct opening on the head. In the chalcidoid *Euplectrus*, however, the cocoon material is supposed to be elaborated in the Malpighian tubules (Thomsen, 1927, Noble, 1936), and discharged through a common duct, the hind gut. Nevertheless the chalcidoids have well developed labial glands. As in the honey bee (Nelson, 1924), the ducts of these glands are thin-walled and similar to tracheae possessing chitinous intima thickened spirally to form taenidia. Bugnion describes the labial glandular tissues as composed of an external cuticle and an epithelium of large prominent cells limited interiorly by a narrow sinuous canal. The ducts of these glands unite and open into the mouth. Dowden (1935) figures these glands in the

second instar of *Brachymeria compsilurae* and labels them silk glands. In the chalcidoid, *Ageniaspis*, Bugnion (1892) observed the "glandes salivaries" and assumed that they secreted the cell forming substance. Although he attempted to locate the "vaisseaux de Malpighi" he was unable to find anything resembling such organs with the possible exception of a single strand of cells situated above the rectum.

Bugnion's failure to locate the Malpighian tubules is explained by the fact that they are closely associated with the labial glands. These glands Bugnion described as voluminous. Parker (1924) who has made a comparative study of chalcidoid anatomy, shows the unique relationship between the labial glands and Malpighian tubules particularly in his figure of *Microterys ferrugineus* (figure 1). The following account is translated from Parker's paper. " . . . The Malpighian tubules are always three in number; they are attached to the anterior extremity of the hind gut; two extending anteriorly on each side of the stomach above the salivary glands; they are joined to the muscular tissue of the stomach by delicate fibers as are the salivary glands; the third tube extends posteriorly and floats freely in the body cavity above the hind gut. The majority of the chalcidoid larvae are characterized by salivary glands that extend backward as far as the posterior extremity of the stomach; the Malpighian tubes are short and never extend forward beyond the posterior third of the stomach. In the larvae of *Spalangia* the salivary glands and the Malpighian tubes are very voluminous; these two organs are made up of large cells that together form a somewhat irregular mass. These glands which greatly resemble each other are attached to each other by delicate fibers. In normal salt solutions these glands may be distinguished by the fact that the cells of the salivary glands are more or less opaque with distinct nuclei whereas the Malpighian tubes are rather transparent with nuclei little differentiated. Also the central canal in the salivary gland is much more distinct than that in the Malpighian tube. . . ." In this connection it is interesting to note that Tiegs (1922) in an exhaustive treatise on *Nasonia brevicornis* observed three "hepatic caeca" opening into the rear of the mid-gut (figure 2). He states that both in structure and embryonic development these caeca differ entirely from true Malpighian tubules.

The primitive number of Malpighian tubules in insects probably is six. In larval Hymenoptera, however, the number of

tubules is generally four (Wheeler, 1893). This rule apparently does not hold for the Chalcidoidea, Serphoidea, and Braconidae. In the larvae of *Chelonus annulipes* they are entirely lacking (Vance, 1932). It is quite probable that all endoparasitic species lack functional excretory organs in the larval stages. Richardson (1913) maintains that such is the case with the ectoparasite *Spalangia muscidarum*.

FUNCTIONS OF MALPIGHIAN TUBULES

In a number of insects the Malpighian tubules have accessory or secondary functions. The larvae of the Cerambycidae (Col.) excrete calcium carbonate, using it to strengthen their cocoons. Certain Lepidoptera use material from the Malpighian tubes to cover their cocoons. The foam or spittle of Cercopid larvae consists in part of Malpighian excretion. In species of Neuroptera (*Chrysopa*) and Coleoptera (*Phytonomous*) a portion of the Malpighian tube is transformed into a silk gland (Wigglesworth, 1934). According to Wigglesworth, one of the important functions of the Malpighian tubes is that of reabsorption of water. This method of water conservation is manifestly unnecsary in endoparasitic larvae since they live in a liquid environment and apparently do not void waste products.

What is the function of the Malpighian tubules in larval Hymenoptera? It is well known that in the Hymenoptera cocoon formation always precedes meconial discharge. Prior to such discharge the hind gut has no alimentary function. In the honey bee larva, fluid excrement accumulates in blind Malpighian tubules, solid excrement in the blind mid gut, and both are voided at the same time prior to pupation (Nelson, 1924). In the Parasitica, on the other hand, the larval Malpighian tubules, which are less voluminous than in the Aculeates, appear to be open long before the meconial discharge. Yet, presumably, they have no excretory function particularly in endoparasites. In the first instar larva of *Therion*, according to Tothill (1922), the Malpighian tubules are blind and functionally quite unimportant. Several authors, however, have observed the discharge of material from the anus of parasitic larvae *before* the meconial discharge.

Triggerson (1914) observed that the early stages of the gall-forming cynipid (*Dryophantes erinacei*) voided a colorless fluid that apparently served to stimulate gall formation. According to Noble (1932) the non-cocoon forming chalcidoid, *Habro-*

cytus cerealellae, voids clear drops of liquid before the opening of the mid gut. Recently Jackson (1937) found that the larva of the ichneumon (*Trophocampa vidua*) while making its cocoon ejected from the anus into the webbing drops of a colorless liquid and after it was finished a small amount of a clear, gelatinous fluid. This material was analyzed and found to consist of chlorides and reducing sugars. The gelatinous fluid contained protein.

The anal secretion of ichneumonoid larvae may be used to give the cocoons of certain species a parchment-like appearance. According to Baker and Jones (1934) the cocoon of *Exeristes roborator* assumes a parchment-like texture after the larva deposits a viscous fluid on the silken strands.

All of the chalcidoid larvae examined by the writer voided a clear, gelatinous fluid either from the anus or the mouth and in some species (*Scutellista*, *Diversinervus*) from both the mouth and the anus.

If the Malpighian tubules produced this substance which, we know in certain species (*Euplectrus*, *Mesopeltis*), is used in forming cocoons, how does it happen to be so similar to the substance produced by the labial glands?

Parker's figure of *Microterys* (figure 1) shows a protoplasmic connection between the Malpighian tubules and the labial gland. The significance of this connection, however, was not realized. A protoplasmic connection between the labial glands and the hind gut, at least in the early larval instars, appears to be characteristic of the Chalcidoidea. This may also be the case in certain groups of the Serphoidea, for Eastham (1929) states that in the early larval stages of *Phaenoserphus viator* the labial glands are connected posteriorly.

It is not surprising therefore that we find the larval Malpighian tubules in the Chalcidoidea similar in structure to the labial glands. This was pointed out by Thomsen in the case of *Euplectrus*. He states that the cells of the Malpighian tubules are large and stain intensely with nucleus stains and are similar to the cells of the labial gland except that the nuclei are more irregular.

ILEAC GLANDS

Since these structures are unlike the true Malpighian tubes in form and function, they will be designated hereafter as the ileac glands. In *Euplectrus* the ileum widens anteriorly

to form a funnel shaped chamber abutting on the mesenteron. The anterior corners of this funnel continue into the walls of the ileac glands. The true Malpighian tubules that usually appear in the mature larvae are connected with the hind gut, caudad of the ileac glands (figure 3).

Histological studies of chalcidoid embryos probably will reveal a protoplasmic fusion between the extremities of the labial glands and the ileum. In some species, as in *Coccophagus* and *Mesopeltis*, this direct connection is retained throughout the larval period. In others, the ileac glands may separate from the labial glands during late larval development. In *Scutellista* the portion of the labial gland in apposition to the ileac gland disintegrates.

During the larval instars the ileac glands appear to increase in volume at a faster rate than the labial glands. In the first stage larva of *Encyrtus* the ileac portion of the combined gland comprises about one-fourth of the total structure whereas in the full grown larva it forms at least one-half of it.

Probably in many, if not in all, endoparasitic chalcidoids the labial glands are connected with the hind gut by means of the ileac glands. In the genus *Encyrtus* this anastomosis is particularly accentuated (figure 3). This genus is unique in that the third (posterior) ileac gland is lacking.

The chalcidoid larvae may be grouped by genera according to the type of anastomosis of these glands. The encyrtids, *Microterys*, *Metaphycus*, *Comperiella*, and *Copidosoma*, are characterized by a labial gland twice bent back upon itself and attached at its posterior bend to the extremity of a small, simple ileac gland (figure 1). In *Encyrtus*, however, the ileac gland is greatly enlarged and forms at least half of the combined structure.

In *Coccophagus* (figure 4) the labial glands, tubular and somewhat convoluted, are attached to the base of the ileac glands which appear to be made up of three large globular cells arranged in series. In *Mesopeltis* (figure 5) the labial glands are straight tubular structures connected posteriorly and likewise joined to the ileac glands. The ileac glands consist of three clusters of large cells; the cells (usually 6 or 8) in each cluster are connected with the ileum by a common duct (figure 6).

Parker's illustrations show four additional types represented by *Perilampus*, *Brachymeria*, *Habrocytus*, and *Spalangia*.

Neither Thomsen (1927) nor Tiegs (1922) observed any connection between the ileac and labial glands. However, they

described a structure which Tiegs called the lateral intestinal gland. The latter author states that, "On either side of the intestine . . . are to be seen in the mature larva two organs, whose existence has not, as far as I am aware, hitherto been

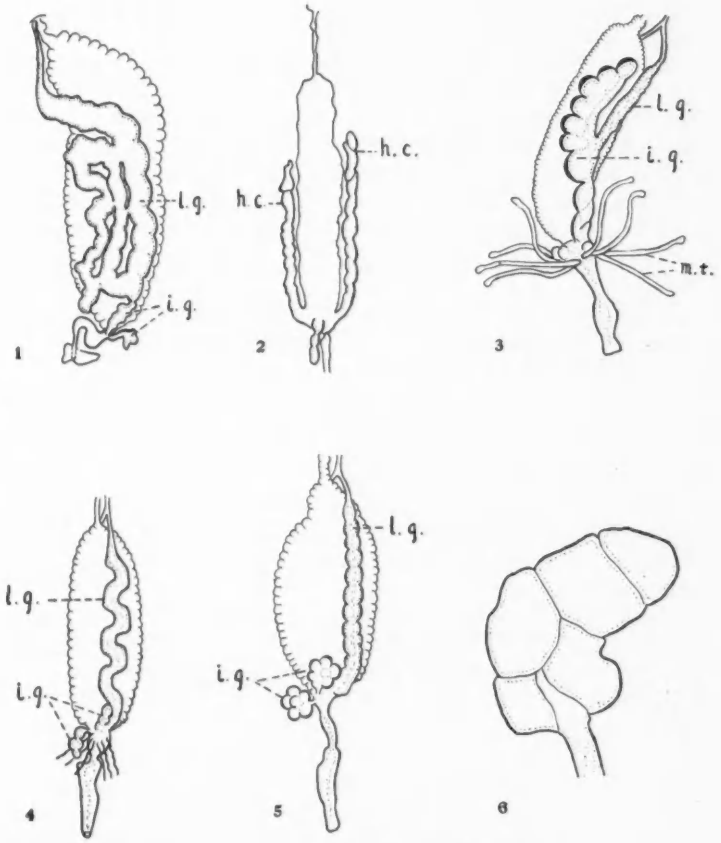

Fig. 1. Digestive system and glands of *Microterys*. (After Parker.)
Fig. 2. Digestive system and "hepatic caeca" of *Nasonia*. (After Tiegs.)
Fig. 3. Malpighian tubules and fused labial and ileac glands in fourth instar *Encyrtus*.
Fig. 4. Malpighian tubules and labial and ileac glands in *Coccophagus*.
Fig. 5. Labial and ileac glands in *Mesopeltis*.
Fig. 6. Ileac gland from prepupa of *Mesopeltis*.

Symbols: l. g., labial gland; i. g., ileac gland; M. t., Malpighian tubules; h. c., hepatic caeca.

observed in insects." This strange organ undoubtedly is the middle portion of the combined ileac-labial glands, probably of the convoluted type.

Functionally the ileac and labial glands appear to be identical. However, the ileac gland differs in not having a distinct central lumen or canal. It is probable that the channels are intercellular (figure 6).

During metamorphosis the ileac glands disintegrate. The true Malpighian tubules, however, appear prior to metamorphosis. Probably they do not become functional until after cocoon formation. Tiegs (1922) states that he observed that in the late larva of *Nasonia* numerous crystals, evidently excretory in nature, begin to accumulate in the fat body and do not disappear from there until the adult Malpighian tubules appear and develop. Then urates appear in large quantities in the intestine.

In *Encyrtus* the Malpighian tubules begin to appear in the next to the last larval instar. In *Mesopeltis* and *Scutellista* they appear during the prepupal period.

The hind gut of both endoparasitic and ectoparasitic chalcidoid larvae is exceptionally well developed and muscular. This is in sharp contrast to the constricted and short fore gut of endoparasites. When dissected in normal salt solution the hind gut exhibits a strong peristalic action. As Thomsen points out in the case of *Euplectrus*, "It is unusual to find a so highly developed differentiation in the proctodeum of hymenopteron larvae, and it seems natural to connect this fact with the special function of the hind intestine in preserving and discharging the web-forming secretion." It is apparent that chalcidoid larvae in general possess the necessary organs for the elaboration and discharge of cocoon forming substances.

SUMMARY

In the chalcidoid larvae three ileac glands usually in conjunction with the labial glands secrete cocoon forming substances. In endoparasitic species the full fed larvae use this material to form a protective and respiratory cocoon within the body fluids of their hosts. The ileac glands probably develop as a result of anastomosis between the labial glands and the proctodeum during embryonic development. In some species a protoplasmic connection between the ileac and labial glands is retained throughout the larval instars.

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THE DRAGONFLIES OF THE BRITISH ISLES, by CYNTHIA LONGFIELD, pp. 1-220, 72 text figs. and 38 plates. 1937. Cloth bound with attractive cover. Published by FREDERICK WARNE & CO., LTD., of 381 Fourth Avenue, New York, and of Chandos House, Bedford Court, London, W. C. 2, England. Price £ 0-7-5 net ($2.00).

It has been thirty-eight years since a general review of British dragonflies has been published. In the meantime in England as elsewhere in the civilized world the appreciation of our rapidly changing fauna has developed with ever increasing speed. Organizations such as summer camps for boys and girls, Boy Scout camps, etc., have opened the doors of nature study in levels of life where such appreciation must have existed but in which there had been no available teachers and (in America) few available books.

In the present neat pocket guide Miss Longfield has given the English lover of nature a quick identification of any dragonfly which might be caught in England. Each species is sufficiently keyed, described and illustrated to make this an easily used manual. Unfortunately only forty-three species of dragonflies are recorded from England. Compare this with a list of nearly 139 from Indiana.

In Europe the recent glaciation brought arctic weather down to the Pyrenees, Alps and Carpathians, largely extinguishing the insect fauna down to these barriers. The English fauna consists of such strays as have managed again to surmount these southern highlands. In North America mountain ranges are north and south in direction. Insects were crowded south, then practically all species followed the retreating ice north again. This fauna in North America is further enriched by a wave of western species which came east after the retreat of the ice and then later were almost completely crowded back after the eastern states became more moist.

We admit that we suffer spells of profound bias for Odonata when such are on the wing. Our experience has been that collecting dragonflies is sport rather than field work in science. Miss Longfield has given us a volume that will be of as much use to the collector who enjoys the sport of the game as to the scientist who more soberly wishes to increase his knowledge of the English fauna. We do not believe that we are too biased when we say that "Dragonflies of the British Isles" will prove to be a very useful work.—C. H. K.

ANATOMY AND HISTOLOGY OF THE WORKER OF CAMPONOTUS HERCULEANUS PENNSYLVANICUS DE GEER (FORMICIDAE, HYMENOPTERA)[1]

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CONTENTS

Material and Technique 181
Digestive System 182
Glands of the Digestive System 188
Poison Apparatus 189
Non-functional Reproductive System 190
Heart and Aorta 192
Nervous System 192
Tracheal System 193
Summary 193
Bibliography 194

The aim of the observations reported in this paper is the investigation of the anatomy and histology of the American *C. herculeanus pennsylvanicus* together with a comparison of this species with the existing work on other closely related Formicidae.

This report describes the digestive system with the associated glands, the heart and aorta, the non-functional reproductive system, and the poison apparatus. The tracheal and nervous systems have not been completely treated, and the blood, the muscles and the sensilla have not been considered at all.[2]

MATERIAL AND TECHNIQUE

The ants used in the study were collected from nests found in tree stumps in the woods at Yonkers in Westchester County, New York. They were taken to the laboratory and fixed in four fixatives: Carnoy's fluid, Carnoy and Lebrun fixative, Bouin's fluid (Kennedy), and Picrochloroacetic fixative (Eltringham). Either the legs were cut off through the femur or small sections of the chitinous body wall were removed to allow the fixatives to penetrate. The material fixed in Bouin's and the

[1]Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Biology at Fordham University.

[2]This problem was investigated under the direction of the Rev. Joseph Assmuth, S. J., Ph. D., Professor of Biology and the Head of the Fordham University Department of Biology. To him I extend my grateful appreciation for both his assistance and interest. Special acknowledgment is due to Dr. William S. Creighton, Department of Biology, College of the City of New York, for classifying the ants and for helpful advice.

Picro-chloroacetic fixatives was washed and stored in 70% alcohol; and the material fixed in Carnoy's was washed and stored in 80% alcohol; while that fixed in the Carnoy and Lebrun fluid was washed, treated with iodine to remove the corrosive sublimate and stored in 80% alcohol. All the specimens were found to be well fixed and preserved for the subsequent technique. Single and double imbedding (Eltringham) was used to prepare the specimens for sectioning. Many of the organs were dissected out and then singly imbedded. This last method produced the best results.

The stains used were Heidenhain's iron-alum haematoxylin counterstained with orange G, and standard alum-haematoxylin counterstained with acid fuchsin. Entire organs and systems were dissected out, stained by Lynch's precipitated borax-carmine method, and mounted (Galigher).

DIGESTIVE SYSTEM

Buccal Tube (Fig. 1). The buccal tube which constitutes the first portion of the alimentary tract is short and dorso-ventrally compressed. Its ventral surface opens into a spheroidal pouch which is called the infrabuccal chamber. The intima of the buccal tube, a continuation of the chitin from the head and mouth parts, is thick and has hair-like projections on its walls which point toward the entrance of the infrabuccal chamber. The hair-like projections of the ventral surface are considerably stouter than those of the dorsal surface. The epithelial cells (and by epithelium I mean, in agreement with Snodgrass (1935 p. 49), the subchitinous cellular layer which was formerly commonly designated as hypodermis) are, likewise, a continuation of the epidermis of the body, but they are more distinct than the epidermal cells. They are built upon a distinct basement membrane and are cuboidal in shape with a centrally located nucleus. Histologically, the infrabuccal chamber is similar to the buccal tube. The intima, devoid of any hair-like projections, is smooth and a trifle thinner. The structure of these two regions agrees with Janet's observations on *Myrmica rubra* (1902) and *Lasius niger* (1905).

Pharynx (Fig. 1). The walls of the posterior part of the buccal tube constrict a little to pass into the pharynx which is flattened dorso-ventrally. The lateral margins of the pharynx taper inward for a little over the first one-half of the entire length. From this point to the posterior end of the pharynx, the sides diverge and the lateral margins curl dorsally and are united at their tips by transverse muscle. Many bands of muscle connect the anterior with the posterior parts of the pharynx, the pharynx with the chitin of the head, and the lateral margins the one with the other.

The studies made by Janet (1894, 1899, and 1905) on *Formica rufa*, *Myrmica rubra*, and *Lasius niger*, and those by Bugnion (1926) on *Camponotus ligniperda*, *C. vagus*, and *C. maculatus* indicate a similarity in the general pharyngeal structure but differences in the shape. The pharynx of *C. h. pennsylvanicus*, just described, most closely resembles that of *C. vagus*.

The intima of this region is a little thinner than that of the buccal

tube but of about the same thickness as that of the infrabuccal chamber. There are no modifications of its free surface until we arrive at the most posterior portion where the post-pharyngeal glands are given off from the dorsal surface and where the ventral surface continues into the oesophagus. Here, the entire surface of the intima is covered with slender, chitinous, hair-like processes which point toward the entrance of the oesophagus and continue for a short distance along the intima of the oesophageal entrance. The epithelium is made up of a flattened, squamous type of cell.

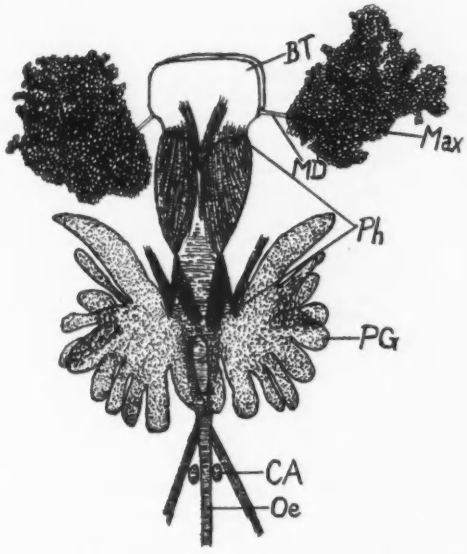

Fig. 1. The first portion of the digestive tube. BT, buccal tube; CA, corpora allata; Max, maxillary gland; MD, maxillary duct; Oe, oesophagus; PG, post-pharyngeal glands; Ph, pharynx.

Post-pharyngeal Glands (Fig. 1). The post-pharyngeal glands are comprised of two groups of finger-like structures. Some of the glandular tubes lie forward, parallel to the pharynx, while some extend laterally, but most of them lie back and overlap the supra-oesophageal ganglia. This is exactly as Bugnion found them in *C. ligniperda*, *vagus*, and *maculatus* (1926), and as Janet found them in *F. rufa* (1894). But, the latter's observations on *L. niger* (1905) revealed two vast, ramifying pouches which occupy all the free spaces in the head.

Histologically, the walls of these glands are only one cell in thickness. The cells are cuboidal in shape with a centrally located nucleus, and the cytoplasm shows secretion vacuoles. The intima of the pharynx continues into the glands as a very thin, chitinous sheet.

Oesophagus (Fig. 1). The oesophagus is a narrow tube which continues through the entire length of the thorax and petiole. There is a slight increase in its diameter after it passes through the neck region, but this again decreases as it passes through the petiole. In the first portion, the intima of the dorsal wall is deeply ridged transversely, but, as we proceed back through the neck region and on toward the end of the oesophagus, the inner surface is thrown into longitudinal folds with the intima on these folds longitudinally ridged. The intima of the middle region is studded with small, sharp spines which point forward. Janet reports that the intima of *M. rubra* (1902) is furnished with fine, sharp bristles directed backward, while that of *L. niger* (1907) is provided in certain places with fine, non-sensitive hairs.

The epithelium is made up of small, fusiform cells located between the longitudinal ridges of the intima. The inner muscle coat is poorly developed and consists of scattered bundles of longitudinal fibers. The outer coat of oblique fibers is, however, well developed. Janet (1907) found branched circular muscle fibers in *L. niger*, but my observations on *C. h. pennsylvanicus* did not reveal these.

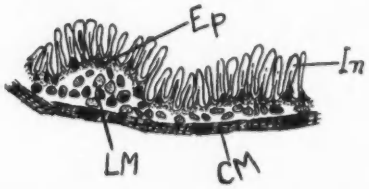

Fig. 2. A semi-diagrammatic drawing of cross section of crop. CM, circular muscle; Ep, nuclei of epithelial cells; In, intima; LM, longitudinal muscle.

Crop (Fig. 2). Just after the oesophagus enters the gaster, it enlarges to form the crop. This is a thin-walled sac, structurally similar to the oesophagus, and its size varies with the amount of food it contains. The intima is as thick as it is in the oesophagus, but the longitudinal ridges found in the oesophageal intima continue irregularly into the crop. These ridges are deepened so as to form folds which lie close together and in cross section resemble the crypts found in the mucosa of the large intestine of mammals. The nuclei of the epithelial cells are larger than those found in the oesophagus. They lie close to the bottom of the crypts of the intima, and may even extend into the spaces between the intima on the ridges. The muscle coat is relatively thin and constitutes about one-third of the total thickness of the wall of the crop. The longitudinal muscle fibers are arranged quite regularly around the entire organ, and the outer oblique muscle is one layer in thickness.

Proventriculus or Gizzard. This region has been very thoroughly studied in the ants by Forel (1874, 1878), Emery (1888), and Janet (1902). Their investigations show that the gizzard is extremely variable in the different genera, but that it furnishes very important characteristics for the classification of sub-families and genera. The following

description of the gizzard of *C. h. pennsylvanicus* agrees very closely with that of *C. ligniperda* as worked out by Forel and Emery.

The crop opens immediately into the gizzard, which is divided into three regions: the calyx or anterior portion which is funnel-shaped, the bulb or middle portion, and the cylindrical section which ends as a knob within the ventriculus. There are four chitinous rod-like bands which extend the entire length of the calyx and which are known as the sepals. They converge at the base of the calyx to form the valve and then bulge out to form the bulb portion. In a cross section of the calyx, each sepal is found to be composed of two wing-like pieces joined together on their outer edge by a semi-circular band. There is a definite opening or gutter in the center of this connecting band which can be seen, under high magnification, to extend between the two wings and into the lumen of the calyx. This separation between the wings is obscured by oblique, chitinous, hair-like processes from each wing which intertwine with those from the adjacent wing. This hair-like band continues over the free surface of both wings of the sepal and is joined to the underlying chitinous portion of the wing along a definite line. The underlying portion is striated, but the striations or hair-like processes of the inner surface are finer and are placed obliquely to the underlying or outer portion of the wing. Forel considered the striations in both portions to be due to a lamination of the chitin forming the sepals. Emery, on the contrary, considered the striations in the outer portion due to fine pore-canals in the chitin and considered the inner layer a hair-border. He observed that an exceedingly thin undifferentiated membrane, which he called the secretion edge, covers the free surface of the hair-border. This secretion edge, he states, is produced by the underlying epithelium and is not chitinous in nature as it resists KOH but is destroyed by Javelle water. Close examination of longitudinal sections of the sepals, which I have made, reveals fine pores in the outer chitinous layer and the secretion layer lying on the hair-border. These observations substantiate those of Emery. The true meaning of the structure of the sepals is, however, still not understood.

The four regions between the sepals are designated as the intersepalary spaces. Here, the chitin is thrown into longitudinal folds and is contiguous with the chitin of the sepals. The epithelium underlying the intersepalary intima is composed of flattened cells, while the epithelium of the sepals is made up of fusiform cells lying at right angles to the sepals. The longitudinal muscle fibers are found only in the intersepalary spaces, and the whole calyx is surrounded by circular muscle.

As we approach the valve, the picture changes. The intersepalary spaces grow smaller as the wings of the sepals come toward each other, until right at the valve they disappear entirely. The adjoining edges of the sepals fuse into wedge-shaped bands projecting into the lumen and reduce it to a cross-shaped space so that the ends of the cross are the gutters of the four sepals. The chitin is unstriated, and the secretion edge and hair-border have disappeared. The epithelium is similar to that found under the wings of the sepals of the calyx; built of fusiform cells, and is located only on the sides and apices of the wedges. There is no epithelium around the gutters. There is one layer of longitudinal

muscle outside of the epithelium, and the entire valve is surrounded by a thick layer of circular muscle. Continuing into the bulb, we find that the chitinous wedge-shaped bands between the gutters rapidly flatten out to assume a convex position. This causes the underlying epithelial cells to lose their fusiform shape and become flattened, and the longitudinal muscle disappears. There is no further change in the structure of the bulb until we come to the base where a slight constriction of the lumen occurs as it narrows to enter the cylindrical section. In this section, the intima is relatively thick, the epithelial layer consists of small squamous cells, and the muscle coat is entirely circular as is that of the bulb. It continues in this form into the ventriculus as the knob which functions as a valve.

Ventriculus or True Stomach. The ventriculus is the largest single structure of the entire digestive system and is roughly elliptical in shape. In the three types of workers (the type of worker is distinguished by the size), it occupies relatively the same amount of space, about one-half of the space in the gaster, and it does not seem capable of much distention or contraction. Histologically, it is made up of secretory cells and regenerative cells built upon a basement membrane. The secretory cells are large with a large centrally located nucleus, and the cytoplasm is spongy. They have a distinctly striated border. The regenerative cells are scattered between the secretory cells in all stages of their development. Their cytoplasm is dense and shows numerous vacuoles, but these cells do not have a striated border. Scattered on the basement membrane and adhering very closely to it are small muscle fibers. They run in all directions and are not arranged in any definite coat.

Intestine. The intestine is a short, narrow, convoluted tube with thin walls at whose anterior end the Malpighian tubules enter. The transition from the ventricular to the intestinal epithelium consists of a gradual change from columnar cells, as we approach the entrance of the intestine, to low columnar cells at the entrance of the Malpighian tubules and to cuboidal cells for the remaining distance of the intestine. After the entrance of the Malpighian tubules, a thin intima covers the epithelium which is folded longitudinally and surrounded on the outside by a muscle coat made up entirely of a narrow band of circular fibers. The posterior end of the intestine is continued into the rectum for a short distance (fig. 3), and the muscle coat surrounding this portion is increased to form a valve-like structure.

Malpighian Tubules. The Malpighian tubules are long slender tubes which lie free in the body cavity. As is typical in the structure of these organs (Snodgrass 1935), the tubules are made up of large cells built upon a basement membrane. Examination of sections of the junction of the ventriculus and the intestine shows the striated border of the ventriculus continuing into the Malpighian tubules. However, the striated border of the tubules changes to a thick coating which almost closes the lumen of the vessel. I have found that the number of tubules varies from 18–21 but that the majority of workers have 20. Wheeler (1926) states that the worker of *Lasius flavus* has 7–8, while Janet (1902) reports 6 for *M. rubra.*

Rectum and Anus (Fig. 3). The rectum is a large sac with thin transparent walls which narrows posteriorly to the anus. It opens on the dorsal part of the sixth gastric segment (fig. 5). Six oval, or lentiform rectal pads are situated on the walls and project into the lumen. The intima is very thin, and the epithelial layer so exceedingly thin that only occasionally can a very small nucleus be seen between its folds. The muscle coat is poorly developed and consists merely of circular and longitudinal fibers scattered over the outer wall. As the rectum narrows to form the anal opening, two changes are observed. The epithelium becomes distinct and forms a definite epithelial layer of small cuboidal cells, while the circular muscle fibers increase in number to form a sphincter muscle.

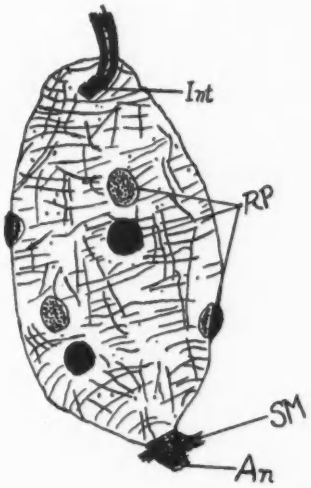

Fig. 3. The rectum with rectal pads. An, anus; Int, intestine projecting into rectum; RP, rectal pads; SM, sphincter muscle.

The rectal pads found in *C. h. pennsylvanicus* are similar to the second type described by Snodgrass (1935) which have a lumen between the epithelium and an outer stratified layer of cells. The epithelium is composed of high columnar cells which extend into the lumen, and their free surface just beneath the intima has a striated border. The outer layer of cells is supposed to be "derived from cells lying originally in the body cavity around the proctodaeum, which gradually approach the rectum and become stratified upon it to form the outer walls of the rectal organs" (Snodgrass). The intima is just as thin over the pad as it is over the rest of the rectum, but it forms a slightly thickened rim around the margin of the pad.

Lubbock (1877) reports that in the ants the number of rectal pads can vary from three to twelve, and Janet (1902) found three in *M. rubra*.

THE GLANDS OF THE DIGESTIVE SYSTEM

Maxillary Glands (Fig. 1). The maxillary glands are two large groups of cells which lie on either side of the pharynx and near the infrabuccal chamber. The main ducts of these glands, of which there are two, one for each group of cells, open on the lateral margins of the posterior portion of the buccal tube. The cells are spherical in shape and have a diameter of 30–32 microns. The nuclei are correspondingly large and centrally located, and dense chromatin nucleoli are seen within each nucleus. The cytoplasm stains deeply with basic stains and contains numerous secretion vacuoles. There is a fine duct leading from each cell which opens into the main duct or one of its branches. Occasionally, a few of the cell-ducts unite before joining the larger collecting-duct, but in the greater number of cases, each cell-duct opens directly into one of the larger ducts. The main ducts and their branches are chitinous tubes surrounded by a film of cytoplasm which contains oval nuclei. The cell-ducts, likewise, appear to be chitinous in structure with a thin film of surrounding cytoplasm and a fusiform nucleus which lies parallel to the long axis of the cell-duct. These nuclei are generally located close to the place where the duct emerges from the cell.

Janet's observations on *Formica rufa* (1894) and *Myrmica rubra* (1899) show that the cell-ducts of these two species open separately on a cribellum into the buccal tube. His study of *Lasius niger* (1905), and the studies of Bugnion on *Camponotus ligniperda*, *vagus*, and *maculatus* reveal the cell-ducts of these forms united into a collecting-duct which opens into the buccal tube. This latter observation coincides with my findings in *C. h. pennsylvanicus*. Bugnion reports that in *C. maculatus* the gland cells are 40–50 microns in diameter which is about 10–20 microns larger than those in *pennsylvanicus*.

Labial or Salivary Glands. The labial or salivary glands are two groups of branched tubular glands found in the dorsal and lateral regions of the prothorax. The collecting-ducts, of which there are two, one for each gland, run posteriorly and ventrally and may even extend into the mesothorax. Here, the direction of the ducts changes suddenly, and they go anteriorly. This change in direction is accompanied by a change in the diameter of the ducts. They swell into large reservoirs or receptacula which lie in the dorsal region of the prothorax just ventral to the glands but more mediad so that their adjacent walls lie against each other along the median line of the prothorax. The ducts leading from the anterior ends of the reservoirs extend ventrally and come to lie one on each side of the oesophagus. They curve under the longitudinal connectives of the ventral nerve cord, unite into one duct, and continue forward between the connectives of the nerve cord through the neck region into the head. The duct lies along the ventral surface of the head, passes below the infrabuccal chamber, and opens between the hypopharynx and the labium into a salivarium.

Histologically the salivary glands, the receptacula, and the ducts are composed of simple cells built upon a basement membrane and are covered with a very thin, chitinous intima. The cells of the ducts and glands are cuboidal, while those of the walls of the receptacula are flattened cuboidal or squamous. Many nuclei of the cells of the receptacula

possess a clear vacuole structure on one side. This has been interpreted by Janet (1907) as a secretion vacuole. The intima of the ducts and receptacula is marked by transverse ridges so that when these structures are viewed in a longitudinal section the intima appears to be composed of a spiral thread as it is in the tracheae.

The studies made by Lubbock (1879) on the salivary glands of *Lasius flavus*, those by Janet (1905, 1907) on *L. niger*, and those by Hilzheimer (1905) on the hypopharynx of an ant which he calls "*Formica ligniperdus*" all agree in every detail with what I have found in *C. h. pennsylvanicus*. But, in *Myrmica rubra*, Janet (1898, 1899, 1904) found no salivary reservoir. The ducts in *M. rubra* are of the same diameter all the way to the glands.

POISON APPARATUS

The poison apparatus is of the pulvinate form (Forel 1878a); it consists of the poison gland, the bladder and duct, and an accessory gland (fig. 4). The bladder, which lies in the posterior dorsal part of the

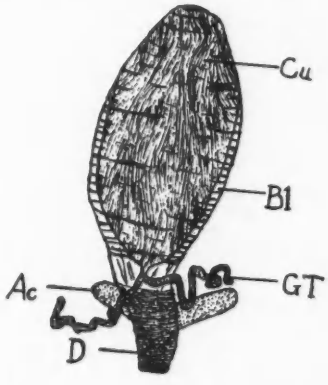

Fig. 4. Dorsal view of the poison apparatus. Ac, accessory gland; Bl, bladder; Cu, cushion; D, duct; GT, free glandular tubules.

gaster, roughly parallel to the rectum, and partially covers the ventriculus, is an elongated sac with thin, transparent walls. The posterior end of the bladder leads into a wide duct which opens on the sixth gastric segment ventrally to the anus (fig. 5). Situated on the dorsal wall of the bladder is a white, elongated, elliptical, flattened cushion composed of a delicate, convoluted tubule which originates in the union of two free glandular tubules found at the posterior end of the cushion. This convoluted tubule opens into the bladder about the middle of the ventral surface of the cushion.

The free glandular tubules are made up of polyhedral cells built around a thin, chitinous, central tubule. There are numerous smaller, chitinous side-branches which extend from the central tubule to the

cytoplasm of the cells. The intima of the bladder is thrown into numerous longitudinal folds, while the intima of the duct is transversely folded. This gives the latter the appearance of being cross-striated. The intima of the bladder, of the cushion, and of the duct is covered by a thin tunica propria, the small nuclei of which can be seen occasionally between the folds of the intima. Thin bands of muscle encircle the cushion and bladder, but there are no muscle fibers surrounding the duct. The posterior end of the duct is a narrow slit-like opening. Around this, the chitin forms a thick band which is encircled by a layer of flattened cells. A heavy band of muscle fibers extends from the opening to the body wall.

The accessory gland is yellowish in color, is bi-lobed, and lies ventral to the duct of the poison gland into which it opens at its posterior end. The cells of the accessory gland which line the lumen are large, columnar cells with fairly large spherical nuclei situated at the proximal ends of the cells. A very thin, chitinous intima covers these cells. On the outside of the gland cells there is a thin tunica propria upon which circular muscle fibers are placed.

This pulvinate form of poison apparatus is confined to the Camponotinae, and my observations on *C. h. pennsylvanicus* affirm those which have been previously made (Forel 1874, 1878a; Dewitz 1877). Forel (1878a) made extensive observations on the glandular tubule which is folded to make up the cushion. He reports that in *Lasius flavus* and *niger*, and in the genus *Camponotus* the tubule is unbranched, while in *Formica rufa, pratensis* and *truncicola* it is branched. The lobes of the accessory gland in *C. h. pennsylvanicus* are longer and more pointed than those in *F. rufa* (Dewitz 1877) and *F. rufibarbis* (Forel 1878a). In *L. flavus* and *niger* the accessory gland is small and spherical (Forel). According to Forel, the yellow color of the accessory gland is due to a fine, granular, pigment-like substance which is located in a space between the tunica propria and the gland cells. My sections show only one or two small spaces between the gland cells and the tunica propria but no continuous space, and no pigment was observed in these spaces.

NON-FUNCTIONAL REPRODUCTIVE SYSTEM

The reproductive system of the worker is similar to that of the queen, but in structure it is less completely developed, and in function it is sterile. The system is made up of two ovaries with a varying number of ovarioles, united by short lateral oviducts to a larger uterus which is compressed dorso-ventrally. The uterus opens ventrally and a little anterior to the opening of the poison apparatus (fig. 5). The ovaries lie below the rectum and the poison bladder, and the ovarioles vary from 1–3 in each ovary. These ovarioles are of the polytrophic type. Each ovariole is covered with a thin, nucleated tunica propria or epithelial sheath. In the region of the immature follicles, the nuclei of the sheath are very small, but as the sheath proceeds toward the bottom of the egg-tube they become more distinct. The sheath continues on to form the ovariole pedicel. If there is more than one egg-tube, the pedicel unites with the other pedicels to form the lateral oviducts. The union of

the lateral oviducts results in the formation of the common oviduct or uterus. At the posterior end of the egg-tube, in the region of the last oocyte, the sheath is surrounded by very fine muscle fibers. These fibers increase to form a definite muscle layer which surrounds the small cuboidal epethelial cells of the uterus. These epithelial cells are internally covered with a thin, chitinous intima. No seminal receptacle was found in any of the workers dissected.

Holliday (1904) reports the following number of ovarioles in each ovary in workers she observed: *Camponotus marginatus* 1, *C. maculatus sansabeanus* 1, *C.* (*Colobopsis*) *abditus etiolatus* 1, with no seminal

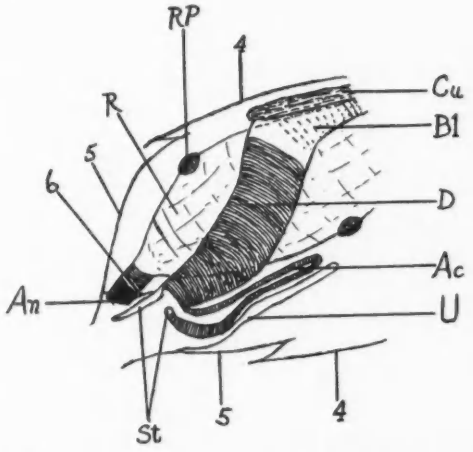

Fig. 5. Sagittal section, diagramatic, through the last segments of the gaster showing the openings of the anus, poison apparatus, and uterus. Ac, accessory gland of poison apparatus; An, anus; Bl, poison bladder; Cu, cushion of the poison apparatus; D, poison duct; R, rectum; RP, rectal pad; St, parts of the rudimentary sting; U, uterus; 4, 5, 6, the fourth, fifth and sixth gastric segments.

receptacle present in any of the above species. But, in *C. fumides festinatus* 2 had 2 tubules on one side and 1 on the other, while 30 had 1 tubule on a side. Of these 32 specimens 2 had the receptaculum situated in the usual position on the uterus between the lateral oviducts, and 9 had a sac-like receptaculum on one tubule. Wheeler (1926) gives the following data: *Formica sanguinea* 3–6 tubules on a side, *Lasius flavus* 1, and *Camponotus herculeanus* 1–5. This latter has 2 more ovarioles on a side than *C. h. pennsylvanicus*.

Weyer (1927) has made an interesting comparison of the ovaries of the workers in *Formica rufa* and *Camponotus ligniperda*. In *F. rufa* he found that the number of ovarioles on a side varies from 2–8 with the greatest number of workers having 3–4, while in *C. ligniperda* the variation is 1–5 with the greatest number of workers having 1–2. He

states that differences in ovary formation are an expression of the differences in the ages of the individuals and that the large eggs found at the bottom of the egg-tubes, which are the oldest, are reabsorbed by the body. In this way, he accounts for the half-empty egg-tubes which are occasionally found.

HEART AND AORTA

The heart occupies the usual position in the gaster just along the mid-dorsal region. It lies above the cushion of the poison gland, and, in the anterior part of the gaster, it is above the crop. Here, it dips ventrally and follows the contour of the body and enters the petiole. The lateral walls are pierced by five pairs of ostia which correspond to the first to fifth gastric segments. On either side of the heart, there are rows of pericardial cells. Both the heart and the adjoining cells are surrounded by a good deal of adipose tissue. The heart is held in position by numerous suspensory filaments and by the alary muscles. The wall of the heart is only one cell in thickness with spherical and oval nuclei which lie along the lateral edges of the tube. Those of the right side are paired with those of the left side. There are no cell boundaries evident, but imbedded within the cytoplasm there are very fine fibrillae which encircle the tube. Under a high magnification (X900), the fibrillae can be seen to possess fine cross-striations.

The heart continues through the petiole and thorax as the aorta and opens into the head. In the petiole, it lies above the oesophagus, but in the thorax it is displaced slightly to the right side of the oesophagus. The cytoplasm of the aorta manifests longitudinal striations, but I was unable to determine whether or not these were fibrillae.

A comparison of my observations on the heart and aorta in *C. h. pennsylvanicus* with those of Janet in *Myrmica rubra* (1894a, 1898, 1902, 1904) and the latter's observations on the aorta in *Lasius niger* (1907) shows that the structure and position is the same in the three species.

NERVOUS SYSTEM

The brain and ventral nerve cord of *C. h. pennsylvanicus* is similar to that of *C. ligniperda* (Forel 1874) and consists of the supra- and sub-oesophageal ganglia with very short circumoesophageal connectives, three ganglia in the thorax, one in the petiole, and three in the gaster. The three thoracic ganglia are large, but the metathoracic is the largest. The remaining ganglia in the petiole and gaster are smaller but are all about the same size with the exception of the last one which is the largest and is formed by a fusion of the three terminal ganglia. A ventral diaphragm which separates the abdominal viscera from the nerve cord is found in the gaster and petiole. This structure also exists in *M. rubra* (Janet 1894a, 1902). The only apparent difference in the ventral nerve cord between *M. rubra* (Janet 1899b, 1902, 1907) and *C. h. pennsylvanicus* is in the three terminal ganglia of the gaster. In *M. rubra* they are still distinct although grown close together, while in *C. h. pennsylvanicus* they are fused into one.

The brain of *M. rubra* and *L. niger* has been investigated by Janet (1899b and 1905), that of *C. ligniperda* by Pietschker (1911), and that of *C. h. pennsylvanicus* by Thompson (1913). For a detailed study of this complicated structure, I refer you to the works of these investigators.

TRACHEAL SYSTEM

Ten pairs of spiracles open on the sides of the body and are arranged so that the meso- and metathoracic pairs and the first abdominal pair are on the thorax, one pair on the petiole, and six pairs on the gaster. Of the ten pairs, nine are small, round openings. The exceptional pair, which is elliptical, is the first abdominal pair and is located on the epinotum or the mediary segment, that segment which is fused to the metathorax. Each spiracle opens by means of a short stigmatic trunk into a lateral longitudinal trunk. In the first segment of the gaster the longitudinal trunks dilate to form tracheal sacs before proceeding through the petiole and gaster to the head. The tracheae which supply the viscera of the gaster arise in groups on the longitudinal trunk directly opposite to the entrance of the stigmatic trunk.

Janet has made a detailed study of the tracheal system and the stigmatic closing apparatus in *M. rubra* (1894a, 1898, 1902, 1904) and a study of the thoracic tracheae in *L. niger* (1907). He found that in *M. rubra* the metathoracic spiracle is closed in the imago although it shows on the body wall but that the stigmatic trunk is present. Krancher (1881) declares that the spiracle openings in *Formica rufa* are oval, but Janet reports that in *M. rubra* they are generally round, as I found them in *C. h. pennsylvanicus*. As far as I have gone in my work on the tracheal system in *C. h. pennsylvanicus*, my observations affirm the reports of Janet in *M. rubra*.

SUMMARY

1. The first part of the digestive system consists of the buccal tube, the infrabuccal chamber, the pharynx with the post-pharyngeal glands, the oesophagus, and the crop. Histologically this region is composed of a flattened type of epithelium externally covered by longitudinal and circular muscle and internally covered by a chitinous intima. The intima bears hair-like processes and spines in some regions, and in the crop it is thrown into crypt-like folds. The post-pharyngeal glands are structurally similar to the digestive tube but do not possess any muscle coats.

2. The proventriculus or gizzard is divided into three regions: the calyx, the bulb, and the cylindrical section. In this organ the intima, epithelium, and muscle coats are very much modified in the different regions. It is similar in shape and structure to other closely related Camponotinae.

3. The ventriculus is a large elliptical-shaped sac which occupies about one-half of the space in the gaster. It is lined with regenerative and secretory cells.

4. The intestine is structurally similar to the first part of the digestive tract, but it lacks the longitudinal muscle fibers.

5. The number of Malpighian tubules varies from 18–21, but the majority of workers have 20.

6. The rectum is a large sac with thin, transparent walls, which bear six rectal pads. The anus has a well developed sphincter muscle.

7. Each cell of the maxillary glands has a very fine cell-duct which unites with a larger collecting-duct. The main-ducts open, one on each side, into the posterior part of the buccal tube.

8. The collecting-ducts of the salivary glands lead into large reservoirs before uniting to form the main-duct which opens into a salivarium between the hypopharynx and the labium.

9. The poison apparatus is of the pulvinate form which is confined to the Camponotinae.

10. The ovarioles of the non-functional ovaries vary in number from 1–3 in each ovary, and they are of the polytrophic type. No seminal receptacle was found in any of the workers dissected.

11. The heart occupies the usual position in the gaster, and it has five pairs of ostia. The heart wall is one cell in thickness, and paired nuclei lie along the lateral edges of the tube.

12. The ventral nerve cord has three ganglia in the thorax, one in the petiole, and three in the gaster. The terminal ganglion of the gaster is a fusion of three ganglia.

13. Ten pairs of spiracles open on the sides of the body. In the first segment of the gaster the longitudinal tracheal trunks dilate to form tracheal sacs. The branches to the viscera arise in groups on the longitudinal trunk opposite the entrance of the stigmatic trunk.

14. In brief, *C. h. pennsylvanicus* agrees in its general anatomical and histological structure with other Formicidae.

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NOTES ON THE SOUTHERN HARVESTER ANT (POGONOMYRMEX BADIUS LATR.) IN NORTH CAROLINA

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Pogonomyrmex badius is not uncommon in the southeastern part of North Carolina and our insect survey records show that it has been taken at the following places: Faison, Hamlet, Southern Pines, Wilmington, Carolina Beach, Spring Garden, Overhills, Rex, White Lake, and Fayetteville. At the latter place I have been interested for several years in its activities and herein give the results of studies made from nests excavated in Cumberland County eight miles south of Fayetteville.

Location and environment. The southeastern part of North Carolina is comprised partly of the sandhill region and partly of the coastal plain proper. The soil varies from almost pure sand in places to a sandy loam. The excavations were made in a location which was just about at the edge of the sand hill country. Here there was a dark loamy topsoil about nine inches thick which was followed by a layer of sand extending down to the seven foot level where a hard, red clay layer began.

The nests were found in various situations such as: in sparse woods, at the edge of woods, in corn fields, and more often in fields that have been out of cultivation for a number of years. One excavation was made in mid-May of a nest situated at the edge of a yard about fifty feet from a dwelling. A scrub oak woods was only seventy-five feet distant from the other side of the nest. The last excavation was made during November in a corn field from which the corn had not been harvested. One nest was observed in the center of a path which extended through sparse (pine and oak chiefly) woods approximately thirty feet from a five acre pond. One walking through the fields and woods of this area can easily locate the nests of *P. badius*.

Shape and nature of mound. On the surface of the ground there is a slight mound or raised level of excavated earth which appears as if one had taken a shovel full of earth and spread it out over a more or less circular area approximately eighteen to

twenty-four inches in diameter. The mound, as I will term it here, is in the strictest sense not a mound but a mere raised level of earth about two inches in height around the circumference and about three inches in height at the entrance cone. The entrance is in most cases centrally located in the mound. Around the outer edge of the area were found large sand grains, bits of clay, debris of various kinds, and curiously enough pieces of charcoal, some of which were as large as three to five mm. square. The nests near the woods had a larger charcoal deposit than those out some distance in the open fields. More noticeable was the deposit of chaff and sprouted seeds around the edge of the nest area. It was not uncommon to find seedlings coming from seeds which had been discarded along with the chaff around the edge of the nesting area. In some cases two mounds would join making a compound nest area but with separate entrances. An excavation of this type of nest shows that the top galleries are connected but the lower ones form separate systems below the one foot level.

Arrangement of chambers. The excavation was generally started at an angle at the edge of the nest area and then as it gradually become deeper the galleries were carefully chiseled out by the use of a hive tool. By this method there was less disturbance of the inhabitants. A short handled trench spade was a very convenient tool for digging to the seven foot level. One can get an idea of how the nest is constructed in Figure 1, Plate I, which is a diagrammatic section made from measurements of a nest excavated in mid-May. At first glance it would appear like a man-made apartment house—not built up toward the sky—but down into the depths of mother earth. This is quite conceivable if one will regard each level as a floor of a building and in this case there are approximately twenty-five floors from the nine inch level to the bottom. In some cases, as in Figure 1, the vegetation grew to the base of the nest area therefore leaving a small cleared area. But this is not always the case as grass was found growing close to the entrance of a nest situated in a sparse woods and a corn stalk was found near the entrance of a nest excavated in November. Also some of the discarded seeds came up and formed new vegetation on the nest area.

The entrance leads into a labyrinth of passages and small rooms which are connected with each other as shown in Figure 1.

These are found immediately beneath the mound and occupy the first nine inches of dark loamy topsoil. The passages run together below the one foot level and thence form a single passage which extends down to the red clay level at a depth of seven feet. Rooms extend off from the passage at various levels as shown in Figure 1. Measurements were made on the distance between floors and are as follows: 1, 2, 2½, 3, 4, and 5 inches. Most of the floors were 2½ to 3 inches apart. The rooms were constructed horizontally and according to the styles shown in Figures 6 to 13. The floor plans were according to three types as follows: (1) one room beneath another (Fig. 13A), (2) rooms alternate (Fig. 13B), (3) two rooms on a floor (Fig. 13C). Building the rooms in an alternate fashion was the most common method although the smaller rooms situated at the top of the nest were built in a stair step fashion as shown in Figure 12. The rooms were shaped somewhat like the sole of a shoe and varied as to the point at which the passage connected with them (Figures 7, 8, 9, 10, and 11). The rooms averaged from 2½ to 3 inches in length and ½ to ¾ inch in depth. The passageway averaged 5 mm. in diameter. The rooms and passageways were surprisingly well constructed in such sandy soil conditions and it was found that the ants had plastered the internal surfaces with red clay so as to give them wonderful reinforcement. Even some of the rooms remained intact after excavation as if one had made a plaster of paris model. It seems quite evident that they dig their nest down to the clay thus obtaining moisture and then carry the clay back up to use as plastering material. In all cases the soil near the clay level was very moist. Figure 6 is a cross section diagram which demonstrates the relative thickness of the hardened walls of a room and a passage.

Workers and brood. During the excavation some of the ants became quite excited and began to carry seeds and brood into rooms that had not been bisected. Some hurriedly tried to repair the exposed rooms and close up the openings with soil. Some rooms were crowded with ants and in some there appeared to be mostly young. In the nest excavated in mid-May brood was found in the upper levels while in one excavated in mid-November brood was found down as far as the five foot level.

Seed stores. In mid-May seeds were stored only in the lower granaries (Fig. 1), but in mid-November seeds were found in

various rooms from the top down to the last floor, however, not on every floor. An estimated two quarts of seeds were found in the November excavation. The following seeds have been identified[1] from this nest: (1) ragweed (*Ambrosia elatior*), (2) crab grass (*Digitaria sanguinalis* [L.[1]), (3) small crab grass (*Digitaria ischaemum*), (4) rough buttonweed (*Diodia teres*), (5) sedge (*Carex sp.*), (6) grass (*Paspalum sp.*), (7) poke weed (*Phytolacca americana*), (8) red clover (*Trifolium pratense*), (9) alfalfa (*Medicago sativa*), (10) evening primrose (*Raimannia laciniata*), (11) narrow leaf vetch (*Vicia angustifolia*), (12) crotonweed (*Croton sp.*). These are listed in the order of predominance with ragweed and crab grass by far the most abundant. There was a large volume of buttonweed present also. The seeds were packed very tightly in the granaries. Some showed signs of mold and sprouting but the greater bulk was well preserved.

The sting. It might be well to give a brief account of the effects of the sting of *P. badius*. Several ants stung me on my wrist and after a few minutes an intense fiery pain began in this area which was about two inches diameter. It turned deep red in color and immediately a watery, sticky secretion came out of the skin. It beaded out like heavy perspiration and ran down my arm. This area became hot and feverish and the excruciating pain lasted all day and up into the night. To get relief I took a very hot bath which caused the intense pain to abate somewhat. Next morning there appeared small blisters over this area which was almost like the appearance of the effects of poison oak. At this time there was still a dull ache in my wrist. In May quite a number of ants stung me on my legs since I wore straight trousers and low cut shoes. The pain was intense for forty-eight hours and it left my legs with a sore and stiff feeling for several days afterwards. Here again real hot water seemed to do more good than anything else in relieving me of pain. The excavation in November remained open for several days. One morning I found a toad on the bottom with a half dozen ants with their stings driven home. He was quite inactive and seemed hopeless until I pulled them off and sent him on his way. Not only can they use their stings expertly but with their mandibles they would hold on so tenaciously to a camel's hair brush that they were decapitated before turning loose.

[1]I am greatly indebted to Mr. J. W. Woodside, of the Division of Botany, who has kindly furnished the seed identification.

The ants did not have their nest altogether to themselves as literally thousands of Entomobryid collembolans were found throughout the nest in nearly every room from the top down to the seven foot level, although they were more abundant in the granaries than in the living rooms.

EXPLANATION OF PLATE

Fig. 1. Diagrammatic vertical section of the nest of *Pogonomyrmex badius*.

Fig. 2. Soldier of *P. badius* with characteristic large head and long hairy beard.

Fig. 3. Frontal view of head of soldier.

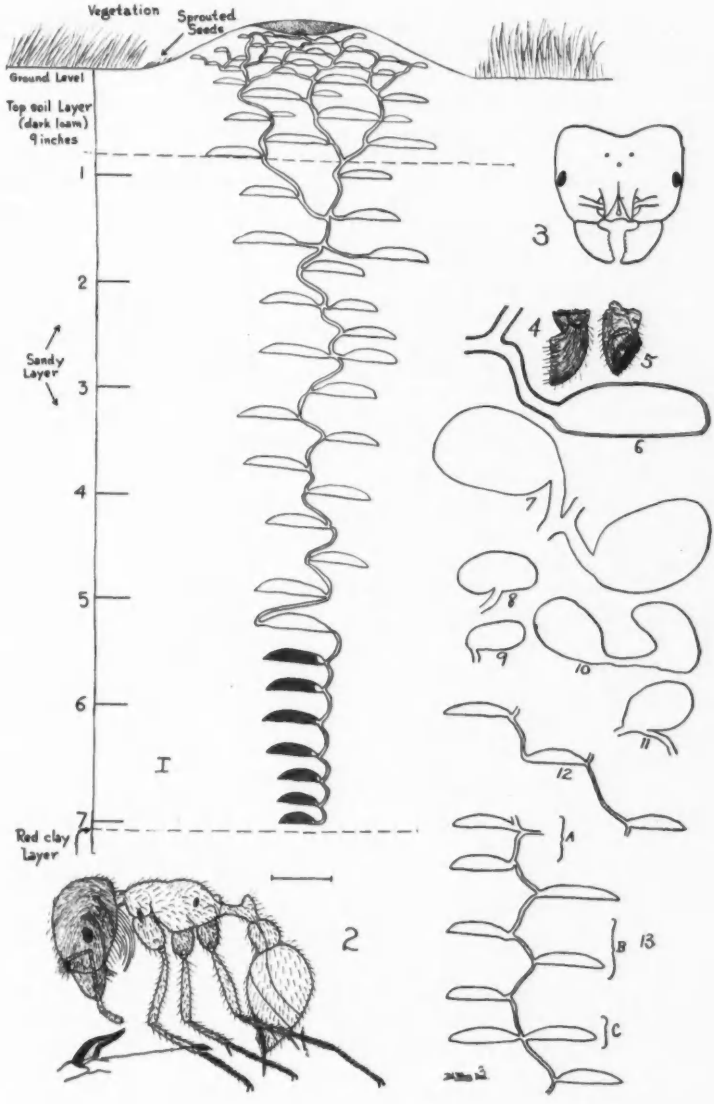
Figs. 4 and 5. Illustrations of mandible of soldier. The mandibles are dentate, shovel-shaped, and large compared to those of other castes.

Fig. 6. Cross-section sketch of room and gallery showing thickness of plastered walls.

Figs. 7–11. Sketches of rooms showing shape and points at which the passage-ways lead to them. Figures 8, 9, 10 and 11 much reduced compared to Fig. 7.

Fig. 12. Diagram of stairway type of rooms at the top of the nest.

Fig. 13. Diagram showing the different ways the rooms are constructed in relation to the floor plan.


Vegetation
Sprouted Seeds
Ground Level
Top soil Layer (dark loam) 9 inches
Sandy Layer
Red clay Layer
1
2
3
4
5
6
7
I
2
3
4
5
6
7
8
9
10
11
12
A
B
13
C

NOTES ON SUNFLOWER CALLIMOMIDAE WITH DESCRIPTION OF A NEW ZAGLYPTONOTUS

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In dealing with insect associations, where several species are involved, it is sometimes difficult to discover the ecological interrelationships among the several groups. This is especially true where a plant is concerned. In such a plant as a sunflower for example, several species of insects occur somewhat abundantly within the head. These include species that are presumably phytophagous, and those that are probably parasitic.

So far as I can determine, there is very little information available regarding the interrelationships of sunflower insects involving *Callimomidae*.

Crawford (1914) established the genus *Zaglyptonotus* with a description of a single species, *Zaglyptonotus schwarzi* Crawford. These specimens had presumably been found in the collection at the National Museum, and consequently nothing was known of their biology. No males were described, and the females had been collected at San Diego, Texas.

Cockerell (1915) collected some specimens of *Callimome sp.* and *Zaglyptonotus schwarzi* in the vicinity of sunflowers, and stated that these inscets may have been parasitic upon the sunflower weevil.

Bigger (1930) found that a species of *Callimome* was definitely parasitic upon the sunflower weevil.

The author reared some specimens of *Zaglyptonotus sp.* from sunflower heads, and stated (Breland MS) that these insects were associated with curculionids.

THE PRESENT STUDY OF CALLIMOMIDAE

On August 26, 1937, large numbers of *Callimomidae* were observed about sunflower heads at Artesia, Mississippi. Investigation showed that these insects were emerging from the

[1]Thanks are due to the following: to Mr. and Mrs. George Kitchens, Artesia, Mississippi, who allowed me to use their sunflower garden for observations; to Dr. C. H. Curran, who determined the *Tryptidae*, and to Dr. E. P. Felt, who determined the *Cecidomyidae* mentioned in this paper.

sunflower seeds. Specimens were collected and compared with a series that had been determined by Mr. A. B. Gahan as *Callimome albitarsi* Huber, which had also been reared from sunflower seed by Mr. A. F. Satterthwaite of the Bureau of Entomology. These insects proved to be the same species. The *Callimomidae* were probably parasitic upon a species of *Cecidomyidae* which was likewise emerging from the seeds at this time. Dr. E. P. Felt kindly determined this dipteron as *Lasioptera murtfeldtiana* Felt. He states that at the time of the original description some years ago, the male alone was described, but that he will probably characterize the female from the series received from the author.[2]

Apparently nothing has been published regarding the life history of this cecidomyid, except that it was originally reared from sunflower seeds. In examining the parasitized sunflower heads, many young cecidomyid larvae were observed among the seed. It is possible that as these larvae grew older, they entered the seeds and remained there until they became fully mature. The extent of infestation of the seeds with *Lasioptera murtfeldtiana* was very great. In some sunflower heads, every seed that was opened was occupied by a cecidomyid or a callimomid, or showed evidence of having been inhabited. Since a small collection of sunflower heads will sometimes net hundreds of specimens of *Callimome albitarsi*, this insect should prove to be an important parasite of this species of *Lasioptera*. Specimens of *C. albitarsi* continued to emerge in the breeding bags in the laboratory until well past the middle of September.

On September 2, 1937, in addition to *Callimome albitarsi*, another species of *Callimomidae* was observed for the first time. This insect proved to be a new species of *Zaglyptonotus*. These insects were flying about the sunflower heads, and several of the females were observed ovipositing. They seemed to prefer heads half an inch to an inch and a half in diameter for oviposition. The insect would crawl about over the seeds until it found a suitable place in which to oviposit. The ovipositor and sheathes would then be inserted among the seed, and oviposition started. The sheathes of the ovipositor were released as soon as actual oviposition began. The abdomen moved rather jerkily during the process, but the insect did not perform a pumping

[2]The description of the female was published after manuscript was submitted for publication: Felt, E. P. 1938. A note on *Lasioptera murtfeldtiana* Felt. Journ. N. Y. Ent. Soc., 46: 44.

motion as has been previously observed in a species of *Callimome*. All ovipositing females that were observed selected heads that were still green in color, but upon which the petals had recently dried. One female oviposited three times within four minutes.

It appeared for a time as though the insects were ovipositing within the seeds themselves. However, opened insect killing vials were placed over several ovipositing females. This killed the insects, which, except for slight muscular contractions, retained practically their normal positions. Upon tracing the ovipositor, it was found that a dipterous puparium was in every case beneath the tip. Many of these puparia were then located. The majority were found within the tissue of the receptacle, but a few were within the shell of half eaten seeds. Some of these puparia contained dead adult *Trypetidae*, but within other puparia, were found pupae of *Zaglyptonotus sp.* The *Callimomidae* pupae emerged in the laboratory several days later as adults.

Many living specimens of the trypetid were obtained, which Dr. C. H. Curran kindly determined as *Tephritis finalis* Lowe. This dipteron presumably consumes the tissues of both the sunflower receptacle and of the seeds. By far the majority were found within the receptacle.

The percent of parasitism could not be determined in the case of either *Callimome albitarsi* or *Zaglyptonotus* sp. Before collections were made, many insects, both hosts and parasites had emerged.

Collections of sunflower heads were made from many localities rather widely separated. In comparison with *Callimome albitarsi*, *Zaglyptonotus sp.* seems to be comparatively rare within the collected territory. Many hundreds of specimens of *C. albitarsi* were obtained, but only 33 individuals of *Zaglyptonotus sp.* One factor that undoubtedly influences this numerical difference, is the difference in number and availability of the hosts. The *Cecidomyidae* were much more numerous than were the *Trypetidae*. It is probable too that females of *Zaglyptonotus sp.* have difficulty in successfully parasitizing trypetids deep within the receptacle of a large sunflower head.

The following is the description of the new species of *Zaglyptonotus:*

Zaglyptonotus mississippiensis new species

Female.—Length, 2.8 mm. to 3.1 mm.; average length about 3 mm. Average length of ovipositor about 4.3 mm. Most of ***head*** covered with a rather dense, white pubescence. Face greenish with a brassy tint. Scape of ***antenna*** yellowish proximally, fading into green toward the distal end. Pedicel green. Ring joint and flagellum black. Basal segments of antenna somewhat longer than broad, the distal segments becoming subquadrate. Segments of club difficult to define. Dorsal portion of ***thorax*** pubescent. Parapsidal grooves sharply defined posteriorly, more fused anteriorly. Other sutures easily distinguishable. Pronotum green, rest of thorax green with a brassy tinge. Anterior portion of thoracic dorsum striate; densely punctate posteriorly, no cross furrow on the scutellum. Mesepimeron piceous, smooth, shining. The secondary epimeral suture represented by a depression. Metapleuron and lateral portion of ***propodeum*** clothed with rather long white hairs. On median surface of propodeum two apposing carinae extend toward anterior and posterior margins, diverge here, and run laterally. The divergence at the posterior margin occurs some distance anterior to the margin itself, so that a triangular region is formed between the diverging carinae and the posterior margin. A row of punctations on the anterior margin of the propodeum. First true ***abdominal*** tergite deeply incised in the mid-dorsal line. On the second, an occasional feeble indication of an incision. First tergite somewhat overlaps the second. Each tergite dorsolaterally clothed with rather long white hairs. The hairs on the fourth tergite extend nearly to the ventral margin posteriorly. Abdominal surface finely reticulated and shining. *Coxae* greenish to greenish blue, femora greenish, tipped with rufous. Front and middle tibiae rufous at each end, grading into greenish brown medially. Hind tibiae rufo-piceous with a greenish tinge distally, becoming rufous proximally. Usually a rufous area at base of hind tibial spurs. Last segment of tarsi greenish black. First segment usually yellow; median segments yellowish to greenish black, those of the hind tarsi usually darker than anterior ones. Hind tibial ***spurs*** very long, the longest nearly as long (never fully as long) as the first tarsal segment. Hind femora feebly denticulate distally, a small tooth near apex.

Male.—Differs from female in sexual characters, and the following: Average length about 2.7 mm. Only a faint indication of an incision medially in the first abdominal tergite. Distal antennal segments somewhat wider than long.

Host: Tephritis finalis Loew. Family *Trypetidae.* (Curran det.)

Distribution: I have collected this insect from the following localities: Mississippi: Artesia, Artesia 5 miles south, Jackson, Meridian, Tupelo 5 miles east. Alabama: Tuscaloosa 17 miles east.

Types: 9 females, 3 males. *Holotype* and *paratypes* in the author's collection. Paratype females in the U. S. National

Museum, and the American Museum. Labeled: two series, first series labeled: Artesia, 9.4.37, Miss., female male, 9.24.37, ex-Tephritis finalis, Curran det., sunflower heads, Breland coll. Second series labeled: Artesia, 5S, 9.5.37, Miss., female male, 9.27.37, ex-Tephritis finalis, Curran det., sunflower heads, Breland coll.

Seems to be closely related to *Zaglyptonotus schwarzi* Crawford, but differs from the published description in having longer ovipositor and sheathes, coloration of antennae and legs, distribution, and length of hind tibial spurs.

Mr. Crawford in his generic description of *Zaglyptonotus* based upon *Zaglyptonotus schwarzi*, states that the longest hind tibial spurs are as long as the first tarsal segment. In *Z. mississippiensis*, although the longest hind tibial spurs are unusually elongate, they are never as long as the first tarsal segment. It would thus seem that this is not a good generic character.

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AQUATIC DIPTERA. 1937. Part IV. CHIRONOMIDAE: Subfamily CHIRONOMINAE, by O. A. JOHANNSEN, pp. 1-52, pls. i-ix. Part V. CERATOPOGONIDAE, by LILLIAN C. THOMSEN, pp. 53-80, pls. x-xviii. Supplementary Notes to Parts I, II and III, pp. 53-56. Published as one fasicle, Memoir 210, Dec., 1937, CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION, Ithaca, New York.

In earlier issues of the Annals we have noticed Parts I, II and III of this authoritative work on Aquatic Diptera. This series of publications brings together and digests in the form of a monograph what has been published on the egg, larval and pupal stages of the aquatic Diptera. To this has been added much information accumulated by Professor Johannsen during the long series of years he has studied these insects in the waters of New York state.

This has been one of the most difficult problems in taxonomic entomology as many species are separated from close relatives more easily by larval characters such as shape and number of teeth in the labium, than are they separated in the adult stage by color pattern, etc., though such species will probably be separated eventually on male genital characters. Many species have been parading under commonly used specific names which on closer studies of larvae, season, and distribution were found to label groups of distinct species. The fragile nature of the material means that too frequently type material is lost or in poor shape. Professor Johannsen patiently and with his unusual skill in drawing and ability in organization has given us a work which will be a new starting point for the numerous students of stream and pond faunas who have been bewildered in their attempts to identify the material they collect in such abundance.—C. H. K.

NEW ANTS FROM STOMACHS OF BUFO MARINUS L. AND TYPHLOPS RETICULATUS (L.)

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In studying the biology of ants in the Neotropical Region many amphibians and reptiles were found to be of significance as predators. The new ants here described were taken with other ants from the stomachs of the giant toad, *Bufo marinus* L., and the blind snake, *Typhlops reticulatus* (L.).[1]

Eciton (Acamatus) ierense sp. nov.

Worker.—Length 1.3–4.6 mm. Head, excluding mandibles, of largest worker distinctly broader than long, of media workers as broad as long, of minima workers distinctly longer than broad. Sides of head in all workers convex, occipital margin in maxima distinctly impressed, in minima transverse or feebly impressed; anterior clypeal margin transverse. Antennal scape clavate, curved outward, 1/10 as long as head in maxima and 5/10–7/10 as long in minima workers. Mandibles triangular with acute apical tooth and three shorter but acute teeth widely spaced on the blade. Thorax from above with sides straight but converging from pronotum to epinotum; in profile feebly convex with distinct meso-epinotal impression. Basal surface of epinotum plane, lower than thorax, rounding smoothly into declivous surface without marginations or tubercles. Node of petiole from above broader than long with convex sides. Postpetiole from above distinctly broader than petiole and broader than long, anteriorly narrowed, anterior and posterior margins transverse, sides convex.

Head, postpetiole, and gaster of maxima worker shining, with deep, setigerous punctations. Thorax and postpetiole similarly punctate with the addition of fine reticulations rendering the surface sub-opaque. Minima worker entirely shining with coarse, setigerous punctations. Mandibles coarsely punctate—striate.

Pilosity of fine, sub-erect, long, and moderately abundant hairs.

Color yellowish brown, darker in the maxima worker. Pilosity golden yellow.

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[1]Dr. Noble (1918, p. 322) mentioned among the ant food of two toads, *Dendrobates tinctorius* (Schneider), in Nicaragua, "*Strumigenys*, 2 species, and *Rhopalothrix*, new species" (det. Dr. W. M. Wheeler). Dr. Bequaert (1922, p. 287) lists these also as above. In 1934 I described (Weber, pp. 52–54) these as *Strumigenys* (S.) *ludia* Mann., ssp. *tenuis*, *S.* (*S.*) *elongata* Roger, ssp. *nicaraguensis*, and *Rhopalothrix* (*Octostruma*) *equilatera*. An additional ant from one of the same toads was described in the above publication (pp. 51–52) as *Codiomyrmex excisus*.

Described from a score of workers taken by myself Nov. 24, 1934, under a log on grassy, sandy ground close to the sea at Mayaro Bay, Trinidad, B. W. I. (*cotypes*), and from a few worker heads taken from the stomach of a *Bufo marinus* March 22, 1935, between 8:30 and 9:15 P. M., St. Augustine, Trinidad (*metatypes*).

This species appears close to *Acamatus punctaticeps* Emery, comparing with the original description, but differs in smaller size, mandibular dentation, and in antennal scape.

The three following new ants were taken from the stomach of a single *Bufo marinus* near the Forest Settlement, Mazaruni River, British Guiana, 10 P. M., August 30, 1935. In the same stomach were a snail, a spider, an adult and a nymph Hemipteran, two beetles, and ants of the following additional species: *Holcoponera striatula* Mayr, *Pachycondyla harpax* Fabr., *Pheidole fallax jelskii* Mayr, *Campanotus* (*Myrmothrix*) *rufipes* Fabr.

Gnamptogenys sulcatum (F. Smith), **bufonum**, ssp. nov.

Worker. Length 3.7 mm. Differing from workers from Kartabo placed by Dr. W. M. Wheeler under the typical form in larger size, broader head (head, exclusive of mandibles very slightly longer than broad back of eyes), eyes more median, longer antennal scapes, and in having fewer and coarser striae on thoracic dorsum. Differing from the var. *nitens* Mann in smaller size, smaller eyes, and in having darker mandibles and antennal scapes. Three workers.

Crematogaster (*Orthocrema*) **brasiliensis** Mayr, **arawak** ssp. nov.

Worker. Length 2.8 mm. Differing from the typical form in having the postpetiolar dorsum entire and not with a median impression, in having posterior clypeal region and frons smooth and shiny instead of microscopically striate-punctate, in having sides of head in front of eyes coarsely punctate-striate instead of finely striate, and in darker color. Differing from the var. *ludio* Forel in being broader in general habitus, with shorter epinotal spines, broader postpetiole, striate-punctate ocular region, and in less regularly striate thorax. One worker.

Procryptocerus goeldii Forel, **guianensis** ssp. nov.

Female. Length 4.6 mm. Differing from the typical form in more rounded head, less sinuate frontal carinae, epinotal spines shorter, anterior surface of petiole not transversely rugose, postpetiole dorsum more longitudinally rugose, and in gaster being much less longitudinally rugulose. Head, with closed mandibles, slightly longer than wide. Color and size similar. One alate female.

Eciton (*Labidus*) **serpentis,** sp. nov.

Worker. Length 2–3.5 mm. Head, excluding mandibles, about 1/5 longer than wide, sides slightly convex, occipital corners evenly rounded, occipital margin straight. Eyes very small, situated posterior to middle of head and dorso-laterally. Antennal scapes clavate, curved outwards, extending posteriorly to beyond the eyes but not to occipital margin. Mandibles triangular, feebly sinuate on outer margin, terminating in acute apical tooth; with edentate distal 1/3–1/2 of blade and strongly dentate proximal half equipped with about five distinct acute teeth and several smaller tubercles. Dentation variable but with at least three strong teeth on blade. Thorax in profile evenly and slightly convex, antero-dorsally reflexed in a slight collar, posteriorly forming with the lower epinotum a slight concavity. Basal surface of epinotum joining declivous surface at an obtuse angle. Thorax from above with convex pronotal sides passing into sub-parallel and narrower epinotal region. Petiole from above rectangular, longer but narrower than postpetiole, the latter with the more massive node and, from above, trapezoidal with rounded corners and greatest width at posterior margin. Gaster small and ovate. Legs moderately long and slender.

Shining, thorax with fine, raised vermiculations, becoming posteriorly and on pedicel fine reticulations.

Pilosity of moderately abundant upright yellow hairs and distally on appendages a short pubescence.

Yellowish-brown.

Described from a series of workers, mostly in fragments, taken from the stomach of a blind snake, *Typhlops reticulatus* (L.) (det. F. Shreve) August 1, 1936, near the junction of the Oronoque and New Rivers of the Courantyne basin, British Guiana. Also in the stomach were far larger quantities of small yellowish-white ant cocoons, evidently belonging to this ant. The snake was some centimeters down in clay of the rain forest floor in the midst of chambers of a colony of *Paraponera clavata* Fabr. In digging up the ant colony I unearthed the snake which was killed within a few minutes by the sting of these fierce ants, one of which stung my knee (see "The Sting of An Ant," *Amer. Jour. Tropical Medicine*, 1937, 17: 765–768, Fig. 1, by the author). Both the snake and the *Labidus* are evidently hypogeic and it is quite probable that the snake is a specialized feeder on this and related ants (*Labidus*, *Acamatus*).

This *Labidus* differs from *L. coecum* (Latr.) workers of the same size in mandibular dentation, less coarsely striate mandibles, smoother integument, and in lighter color. It differs from *L. praedator* ssp. *emiliae* Mann workers of the same size in

mandibular dentation, much smoother dentation, and in color. Unfortunately no soldiers were present in the stomach so it is not possible to compare this caste.

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THE AXIOMATIC METHOD IN BIOLOGY, by J. H. WOODGER, with Appendices by Alfred Tarski and W. F. Floyd. Pages i-x and 1-174. 1937. Cloth bound. Published at Cambridge (England) by the UNIVERSITY PRESS or to be had from THE MACMILLAN COMPANY, 60 Fifth Ave., New York. Price $3.75.

This volume is on the borderline between prose English and the language of mathematics. It is a vivid protest against the use of poorly defined terms and the general sloppy thought to be found in much biological "literature."

Professor Woodger is a biologist and in the volume argues for a prose and prose symbols which are exact enough to be handled logically as are mathematical expressions. "Because if we have a perfect language we need not dispute, we need only calculate and experiment." The author opens his discussion: "In reference to any branch of natural science we can distinguish: (1) the *objective reference* or subject matter, (2) the *work* or *activities* of the men and women engaged in it, (3) the *language* in which the results of their labours are recorded and communicated. We call scientific work *practical* if it is directed towards (1), *theoretical* if directed towards (3)." This volume deals with item (3).

Two chapters are devoted to a discussion of the nature of the problem and a third chapter in nine sections is given over to a sketch of a biological axiom-system, the relationships of parts to each other, of groups of parts to other groups and of parts to the whole.

"In biology we have a great wealth of empirical data and little or no 'system' or it may be, modes of systematization of an unsuitable kind incapable of further development. If we wish to axiomatize such a science, in order to make it more tidy and manageable and its implications more explicit, either we may hunt for an existing uninterpreted axiom-system which has the requisite form, or, taking the branch of science as it is, and armed with an understanding of the axiomatic method, we may devise a system especially for the purpose." Chapter III is the author's outline of an axiom system for embryology, genetics and taxonomy.

This, of course, is only one of a variety of similar, possible systems depending on the assumptions involved. However, it is an attempt to organize biological theory which in development has always lagged behind the collection of empirical data. In biology explanations usually follow the discovery of relationships. In the more exact sciences various explanations of relationships in hypothetical situations come later to application in subsequently discovered objective situations. Thus in the lack of the development of the logistic method by biologists the latter lack a tool of great use in the development of biological theory. The usual explanation of this hesitancy of biologists, to work with theory as theory, is that the biological world is so vastly complex as compared with the subject matter of the present-day exact sciences.

We recommend the work to those logically minded readers who hope to give us a better system or philosophy of biological principles. We recommend it to all who are irritated by the numerous teological terms and other expressions in current literature.—C. H. K.

RECENT PROGRESS IN THE STUDY OF SOME NORTH AMERICAN MIGRANT BUTTERFLIES

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In 1930 I published in my book "The Migration of Butterflies" a summary of the available knowledge of the migrant butterflies of North America, including about thirty species of which the principal were the Monarch (*Danaus plexippus*), the Painted Lady (*Vanessa cardui*), the Migrant Yellow (*Catopsilia sennae*), the Southern White (*Pieris monuste*) and the Snout Butterfly (*Libythea bachmanni*).

Since that date a considerable amount of new information has been received or published and some older records have been found which were previously overlooked, so it seems desirable to review this new knowledge, to see how it bears out previous conclusions, and to show where are the many gaps in our information.

The following species are discussed below:

Danaus plexippus (*menippe*)..... The Monarch..... 211
Vanessa cardui..... The Painted Lady..... 219
Ascia monuste..... The Great Southern White..... 223
Phoebis eubule..... The Migratory Sulphur..... 226
Kricogonia lyside..... The Lyside..... 230
Eugonia j-album..... The Compton Tortoiseshell..... 231
Eurema lisa..... The Little Sulphur..... 231
Vanessa californica..... The Californian Tortoiseshell..... 232
Pieris rapae..... The Cabbage White..... 234
Libythea bachmanni..... The Snout..... 236

Danaus plexippus (L), The Monarch

In my previous summary a large number of records of mass flights and swarming were collected and discussed.

It was considered that the evidence was in complete support of the theory of a southward movement of the butterfly, starting in Canada and the Northern States in August and September and reaching the Gulf States and Southern California about October. There was evidence of hibernation in mass in some localities in Florida and Southern California. In the spring the evidence of a return flight from actual observation was small, but it was considered that the flight must occur and was

overlooked because it appeared to take place without any gregarious instinct; the butterflies flew singly and escaped attention. The northern areas were thus repopulated by migrants from the south, which laid eggs as they proceeded northwards. The return migration to the south started after one, two or three generations, according to latitude and temperature.

The new evidence that has now come forward is summarized below under three main headings. (1) The Spring Flight, (2) The Autumn Flight, and (3) Hibernation.

The Spring flight.

(1) Wright (1906, p. 24) says that he has seen numbers gathering both in the spring and fali in Texas.

(2) Calkins (1932) says that in Kansas battered examples are seen passing north in April.

(3) Hancock (1886) says that during the fore part of June, 1886, unusual numbers migrated through Chicago. They flew at a rapid rate along the streets to the north. On the 12th of June they were equally common and restless at "Lawn Wood" a few miles to the South, only stopping for occasional moments. He captured many specimens by using dead ones as decoys.

(4) Wymore (1937) says that on March 20, 1937, thousands were observed at the Eastern edge of Ventura City, California, flying north towards the mountains.

(5) Mr. J. A. Comstock, writing from Los Angeles, California, on May 4, 1932, says, "The aestival migration is observed every spring here but in this case the butterflies do not show the swarming instinct and are always travelling singly."

The Southward Autumn flight.

These records are summarized as briefly as possible below. If a date appears after the name at the end a fuller account has been published to which reference will be found in the bibliography; if no date appears the record is previously unpublished.

(1) Year unknown, in November. At Consul, Alabama. Thousands spent the night on a short leaf pine (L. B. Robertson).

(2) Year unknown. At Gainesville, Georgia, flying to the south. A flight and massing for about 3 days (reported to A. G. Richards).

(3) 1892, October 22. At Austin, Texas, flying to the south. From 20 feet up to as far as the eye could see. Cloudy, little or no wind. (Dumble, 1892).

(4) 1894, end September. At Chicago, Ill., flight to S. E. Immense flocks streaming every afternoon, reported by friend. (Denton, 1900).

(5) ? 1898, December 1. In central Iowa, flying to S. For 30–40 minutes air full up to 300 feet or more. (G. M. Brown).

(6) 1898 or '99. In New York City, flying to W. or W. N. W. Majority at height of about 3rd story. Millions. (L. W. Hull).

(7) 1899, fall. At Austin, Texas. Swarming on a pecan tree so thick that the branches drooped. (Brues, 1926).

(8) 1907 or '08, end September. At Brookings, S. Dakota. Hundreds of thousands, all gone next day. (Matheson: Williams, 1933).

(9) 1907 or '08. In Kansas, flying to south. Great numbers from near the ground to as far as eye could see in the air. (L. M. Dewey).

(10) 1915, September 17–23. At Charles City, Iowa, flying to S. E. Flock of many thousands. 37 captured with one sweep of net, with many *Colias philodice*. (Fenton, 1919).

(11) 1916, September 5. At Charles City, Iowa; flying to S. E. Main migration started on the 11th with some *C. philodice* and *P. rapae*. (Fenton, 1919).

(12) 1916, September 21. At Iowa City, Iowa, flying to S. W. Several thousands appeared at 3 P. M. with strong wind from N. E. All gone next day. (Wickham, 1916).

(13) 1916 or '17, winter. At Pensacola Bay, Florida, flying to N. Flying from Santa Rosa Island to Fort Banencas; took 10 minutes to pass. (M. B. Davis).

(14) 1917, August. Near Toronto, Ontario. Swarms seen in High Park, Mimico, and streets of town. (Gibson, 1918).

(15) 1917, end August. At Charles City, Iowa, flying to S. E. With *Colias philodice* but no *P. rapae*. Max. flight 12–15 September. (Fenton, 1919).

(16) 1917, Sept. 2. At Kew Gardens, Toronto, flying approximately to S. After congregating for some days they flew off over the lake in a dense cloud. (Andrews, 1919).

(17) 1918, mid-September. At Ozana, Texas, flying to S. Flight lasted three days, so thick that one could catch a handful. Houses were filled. (M. R. Reimers).

(18) ? 1922, end August or early September. Near Toronto. Massing on tall trees. (N. G. Tippett).

(19) 1922–27. At Chiloothe, Missouri. Seen many times in mass flights during this period. (J. Deal).

(20) ?1922. Near Medford, Oregon. Auto-radiator blocked by swarm of butterflies. (M. Carle).

(21) 1923, August 24. At Toronto. Congregated for two days on maple trees, third day all gone. (Hutchings, 1923).

(22) 1923, August 30th. At New York City, flying to S. Drifting more or less with the wind according to a newspaper report. (Hutchins, 1923).

(23) 1926, ? mid-August. At Pittsburgh, Pa., flying to S. W. Great swarm filled air for about half hour. Stragglers for longer. From 10 feet to above housetops. (E. A. Patterson).

(24) Between 1927 and 1931, September. At St. Louis, Missouri, flying from N. E. Large swarm came in one afternoon and settled for night. Early next morning all gone. (M. S. Young).

(25) 1928 or '29, about October. At Pittsburgh, Pa., flying to S. W. Scattered groups of 2–12 for about 1½ hours. 300 crossed 100 foot front in half hour. Cold day. (E. A. Patterson).

(26) 1928 or '29, mid-September. At Cisco, Texas, flying to S.

Passed during one morning to as high up as could be seen. First time noted in 13 years. (M. R. Reimers).

(27) 1929, September 2. At Sedan, Minnesota. Massing in evening on tree; all gone 8 A. M. next day. 27 males and 13 females captured. Denning (Williams, 1933).

(28) 1930, September 17–24. At Washington, D. C. Gradually became more gregarious and then disappeared (Clark, 1932).

(29) 1930, early October. At Corsicana, Texas. Thousands settled on trees in late afternoon. All gone early next day. Only observation in 10 years. (E. R. Evans).

(30) 1930–36, last half of September. At Arlington, Mass., flying to S. W. Three or four flights seen in different years; on one occasion for 3 days, flying 7–10 m. p. h., weather sunny with little wind. (T. W. Barnard).

(31) 1930, fall. At Charleston, R. I., flying to W. Large flight for several days on the beach. (H. M. Stanton).

(32) 1930, August, 2nd week. At Port Hope, Ontario, flying to S. E. Large flight in a 5 acre wood so thick that noise of wings audible. Hot and dry day. (W. Price).

(33) 1930, September end. At Oak Island, L. I., flying to S. W. Flying 3–6 feet from ground, at night weighed down bushes. (E. Kelley).

(34) 1931, September 24. At Solomons Island, E. Maryland. Swarm appeared for one night; next night only stragglers. (Cory: Williams, 1933).

(35) 1932, August 3. In Sacramento Valley, Cal., flying to W. Huge migration seen for fifteen miles, said to be a regular occurrence. (J. M. Carle).

(36) 1933, September 20 or 21. At Little Compton, R. I. Appear regularly every year following the shore line, and settling on higher branches of trees. (L. Baird).

(37) 1933, September 25. At College Park, Maryland, flying to S. About 300 seen. (Cory, 1933.)

(38) 1933, October 1. At Potomac Park, Maryland. Large numbers congregating. (Sanders, 1933).

(39) 1933 or '34, October 3 or 4. At Boston, Mass., flying to S. W. Thin flight; 15 m. p. h. at least. Wind light S. W. Sky cloudless but hazy. (T. W. Barnard).

(40) 1934, August ? 21. At Oswego, N. Y., flying to S. Clouds reported so thick as to darken the sun. (Newspaper cutting).

(41) 1934, September. At Mystic, Conn., flying to S. Swarm settled on maple tree for night; all gone next day. (H. M. Stanton).

(42) 1934, September 27. From May's Lick, to Lexington, Ky., flying to S. Singly or in twos or threes along highway; 48 seen in one mile. (H. E. Ransier).

(43) 1934, mid-October. At Indianapolis, Ind., flying to S. Number increased for a week and finally occupied area ¼ x ⅛ mile. (C. S. Hendricks).

(44) 1934, October 2–4. At Piney Point, Maryland. Main body left on 2nd October; on 4th 200 stragglers were marked with a green dye. (Cory, 1934).

(45) 1935, September. At Port Penn, Delaware. Many thousands on oaks up to 50 feet from ground; remained about 10 days. (C. H. Thomas).

(46) 1935, September. At Brooklyn, N. Y., flying to S. W. Flying at a height of 50 to 100 feet, wind strong W.; later wind weakened and flight higher. (H. Mahnken).

(47) 1935, end September or early October. At Two Rivers, Wis. Swarm completely covered a pine 50–60 feet high. (H. G. Appleby).

(48) 1936, September. Near McCarney, Texas, flying to S. Swarm of thousands. (M. R. Reimers).

Hibernation. California.

(1) Mr. J. A. Comstock, of Los Angeles Museum, writes (4th May, 1932): "Certain groves of Eucalyptus in the region of Santa Monica and Laguna Beach have come to be known as "butterfly trees" because of the frequent gathering of *plexippus* there. It is my personal opinion that some of the imagos of these flights overwinter in Southern California and in lower California, whence they produce a brood that gives us a northern flight in the spring."

(2) According to Mr. N. L. Fitzhenry another of the winter resorts of the Monarch is at Stinson Beach, Marin County, California. In 1931 he wrote as follows: "About 50 miles from the coast they appear to loiter and scatter, arriving here leisurely up to November and December. Our garden is full of them now (5th October). They select the same tree or group of trees each year as their roosting place, a protected spot open to the sun. These are known as "butterfly trees" and are usually Cypress or Eucalyptus.

(3) According to Mr. F. T. Scott, he has seen colonies of Monarchs during the winter between Pismo and Oceano in San Luis Obispo Co., California. The butterflies "hang as thickly as they can manage in Eucalyptus trees." Mr. Scott saw them in February for several years in succession and particularly in 1928 and 1929, but has not been there since the latter date.

According to reports which he received these resting places occur all along the coast as far as San Diego Co., but he was unable to visit any other localities personally.

(4) In 1914 Miss L. Shepardson published a small booklet describing in popular language the "Butterfly trees" at Pacific Grove, Monterey, California. She states that there was "authentic information" that the butterflies had been seen hibernating in the same locality fifty years previously. The butterflies arrived usually about the second week in October and began to disappear about the first of March.

More than 20 years after this we have evidence that the same phenomenon continues. Mr. M. Doudoroff writes to me (5th July, 1937): "the butterflies come here about October 8th, flying from the North. They apparently cross Monterey Bay and land on Pines and Cypress trees about half a mile from the shore. For many years they came to the same trees each time. According to reports, however, they were molested by children and changed their hibernation quarters to another group of trees about 200 yards further in the forest. In 1936 they

appeared a bit late, about October 15th, and landed on about five trees some 500 yards from their previous location.

"They are said to leave between the first and fourth of April and fly north, crossing the bay, a large proportion of them, however, remain in the peninsula, feed and pair almost immediately." Mr. Doudoroff does not know of any milkweed in the region, nor has he seen any larvae, but these were reported to be a pest in a garden in Carmel Valley, about 20 miles away, during the summer.

Hibernation. In Florida.

According to my previous summary hibernating swarms of Monarchs had been reported in Florida at Apalachicola and in the Everglades.

(5) Mr. W. F. Smith informs me that on November 21, 1934, he found a considerable colony of Monarchs hibernating in a grove of gnarled "live oaks" at Englewood, about 30 miles south of Sarasota on the west coast of Florida. "They were not very active and for the most part were clustered close on what appeared later to be favorite branches. A few would occasionally fly off and flit about in the sun, to return to the roost." They were seen again on the following day, November 21st, and again on February 23, 1935, they were as before, but a few days after this none were to be found.

A second colony was visited on January 4, 1936, in a pine wood east of Englewood, consisting according to his estimation, of 400–500 individuals. They were in a second growth grove of slash pine trees averaging about 50 feet high. They were visited frequently and were present on February 4th, but all had gone on February 19th. Mr. Smith writes "if the wind was blowing from the east and a bit strong they would be found at night in the west side of the trees, and if from the west, they would be found on the east side, and almost always on the *same* tree. I examined a large number both at close range and in hand, and did not find a broken-winged, or frayed specimen. Nor were there signs that the other creatures in the wood disturbed them or gathered to feed upon them."

Mr. H. E. Ransier, who accompanied Mr. Smith on several visits to these two localities thinks that the number of butterflies was greater than Mr. Smith estimates, and he would put it at about 2,000. The temperature in the district while he was there went down one night to 24° F. and newspapers reported it as low as 19° F.

On January 9, 1935, he noted in his diary that mating was taking place.

(6) Mr. W. F. Smith writes (in 1937) that several years ago a friend reported the presence of a large roost of Monarchs on the pine woods at Homasassa on the west coast of Florida. He was unable to visit the locality himself.

(7) According to Mrs. W. G. Colvin, of Davenport, Florida, Monarchs are not seen there except in the winter months. In 1936 they appeared when the Poinsettia bloom about December 1st and stayed as long as it lasted. H. T. Fernald (1932) said that in the winter of 1931–32 the Monarch was common at Orlando until the end of February and then disappeared.

(8) Fernald (1937b) reports that on January 16th, 1937 he found eggs, larvae up to one inch long, and four chrysalids of the Monarch at Orlando, Florida. This is the first record of breeding taking place in the winter months.

(9) Mr. T. Cooper, assistant keeper at the St. George Light Station, situated on St. George Island, about nine miles off shore south of Apalachicola, Florida, reports (September, 1937) that every winter for the past six years large numbers of Monarchs have hibernated on St. George Island, which is about 35 miles long by 1–1½ broad. They fly across the bay from the mainland in the autumn with a fair wind from the N., N. E. or N. W., flying only a few feet above the water and at a speed of about 6 m. p. h. They are not seen out at sea south of the Island nor has he noticed them going back north in the spring. Practically none are seen during the summer months. In 1937 a small flight arrived about September 1st and a much larger one about the 10th (letter written on September 13th) but very few "as yet." Mr. Cooper thinks that they stop coming about mid-October but he will take more definite observations this fall.

The Island is heavily wooded with long leaf Pine and Cabbage Palmetto, and with a dense undergrowth of Saw Palmetto and Scrub Oaks in places.

Hibernation. In Indiana?

As reported in my previous review Shannon (1916) on a map indicated that Monarchs had been found hibernating as far north as Vigo Co., Indiana. He gives no reference and no information has come to light since 1930 to lend any support to this suggestion.

DISCUSSION

The new evidence lends strong support to the existence of the spring flight towards the north, and also to the idea that the insects are much less gregarious on this flight than in the autumn.

The new records relating to the autumn flight almost double the information available, and it was considered worth while at this stage to consider the geographical distribution of all the known observations. This is shown in Fig. 1, which in addition shows the recorded localities for hibernation. An inspection of this map shows first of all that the Monarchs seem to avoid the main chain of mountainous country along the "Rocky Mountains" in the west.

Secondly, it will be seen that there are a large number of records of flights in the New England States, New York and the States bordering on the Great Lakes, where the population is high and the number of people interested in insects rather large.

The trail of the southward movement can be most easily

followed through Iowa, Kansas, Oklahoma and Texas away apparently into Mexico. On the Atlantic coast, in spite of a large number of records in the north, there are surprisingly few in Virginia (except near the District of Columbia) in North and South Carolina, and in Georgia; although the presence of large numbers hibernating in Florida must almost certainly mean that the southward flight continues through this area.

Perhaps the most unexpected gap, however, is that in the States of Tennessee, Alabama, Mississippi, Arkansas and Louisiana. Not a single record of massing or of directional flight has

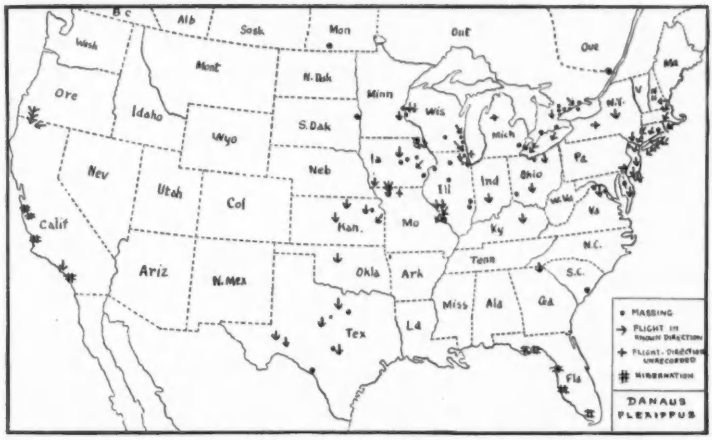

Fig. 1. Flights of *Danaus plexippus* showing also massing and hibernation localities.

been made, so far as I can find, for this large area. In Alabama the negative evidence is even more definite as Mr. P. H. Smyth, who has observed the migrations of *Catopsilia eubule* for over seventeen years (see below) has never seen flights of Monarchs and says that the species is quite rare in the district around Montgomery, Alabama.

There is the large gap of the great mountain ranges already mentioned (in which, however, other migrants, as for example, *Vanessa cardui*, are not infrequently recorded) and then a further series of records along the Pacific coast with a second hibernating area in Southern California, which is considerably further north in latitude than the Florida areas, but in about the same winter isotherm.

There are no hibernating quarters yet recorded in the whole of the Gulf Coast and Mexican frontier between Florida and California. In the west they undoubtedly carry on into Mexico. On the Gulf Coast we have not yet any evidence of their arrival from the north, and no records anywhere of any movements out to sea towards the West Indies and South and Central America.

Only the accumulation of more and more records can show whether the distribution of flights and hibernation as shown in Fig. 1 is real or accidental, and we appeal to all naturalists to send in their observations on this common but most interesting butterfly.

Vanessa cardui (L.), The Painted Lady

In my previous survey the migratory habit of this butterfly was well established, and it appeared that the chief invasion occurred through Southern California.

The new information now available, establishes even more firmly the above conclusions and provides further material for a possible analysis of periodicity of outbreaks or the relation of the migrations of this species to those of others.

(1) 1899. According to Ricker (1906) *cardui* was in thousands in western Montana in the spring of this year.

(2) 1907. Los Angeles, California. According to Haskin (1933) there was a great flight towards the south. No month is stated.

(3) 1924, April 13th. Salt Lake City. *V. cardui* suddenly appeared in large numbers, many flying in pairs. For a week they were still numerous but flying singly. Lighter in color than the usual mid-summer specimens, and in good condition. 30–35 were collected in a few minutes without moving from one spot. J. W. Sugden (in letter).

(4) 1924, April. Tulare, San Joaquin Valley, California. Tremendous swarms drifting to the N. West. (Haskin 1933). The month is not given in the original, but is apparently April.

(5) 1924. In this year the insect was very widespread in the U. S. A., and during June and July records of great abundance of both insects and larvae are reported from Indiana, Wisconsin, S. Dakota, Ohio, Michigan, Illinois, Minnesota and Oregon, particularly in the pages of the "Insect Pest Survey Bulletin." It was, according to A. H. Clark (1932) the commonest butterfly in Essex, Mass. It was also common in Georgia from 1924–1927, but rare for some years afterwards according to Richards (1931). In Delaware larvae were attacking hollyhock in mid-June (Houghton).

(6) In 1926 there was again a very large immigration, and several very large mass flights in California were mentioned in my previous summary. The butterfly or its larvae were reported to be abundant in California, Indiana, Illinois, Minnesota, Wisconsin, District of Columbia, and in Canada in Alberta and S. W. Ontario. Also in Georgia as reported above.

From 1927–1930 inclusive, no report of the occurrence of this species occurs in the "Insect Pest Survey Bulletin," and Clark (1932, p. 91) reports it wholly absent in D. C. in 1928, 29 and 30.

(7) In 1930, on March 30th, *V. cardui* suddenly appeared in numbers in Salt Lake City, Utah, and continued common for several days throughout the entire city. "3–8 were seen on the length of a city block." All had disappeared by April 10th. (J. W. Sugden in litt.).

(8) In 1931 there were again extensive migrations. A large migration towards the north was reported from various localities in Utah in the spring. According to J. D. Sugden (in litt.) the date of appearance at Salt Lake City was May 3rd, when many were flying steadily in a more or less direct course all over the City at 3–20 feet above the ground. None were noted mating or hovering around. At Richmond, Utah, according to a newspaper report (which identified the butterflies as *Argynnis aphrodite*) countless thousands, all flying north, were observed for three days on the highways from Beaver City to Provo, a distance of about 150 miles.

The butterflies or their larvae were reported in Vermont, Minnesota, Massachusetts, Maine, Ohio, Illinois, Indiana and Iowa. The situation is summarized in the "Insect Pest Survey Bulletin," XI (10), p. 678, "During late June and July the larvae of the Painted Lady became very numerous in the New England States, and in the entire upper Mississippi and Ohio River Valleys, covering the E. Central, N. Central and W. Central States." In Canada they were abundant in Alberta.

There is again no mention of the occurrence of the Painted Lady in the "Insect Pest Survey Bulletin," of 1932, 1933 or 1934.

(9) On January 1, 1934, Dr. T. D. A. Cockerell (1934) saw a single unusually small specimen at Boulder, Colorado. This is the first record that I know of the existence of the species in this part of the U. S. A. in mid-winter.

(10) In 1935 there was again considerable renewed activity. Cockerell (1935) reports that he first saw them in great numbers early in March in the East side of the Cayamace Mountains and in the Borego Valley, San Diego County, California. Martin Brown (1936) motored for about five hours through a dense awarm flying towards the north, on March 27th, between Lourdsberg, New Mexico, and Coolidge, Arizona. The same author reports that they descended on Colorado Springs, Colorado, on May 10th. The following day the numbers were estimated at 20,000 per acre on the lawns, 8,000 per acre on the alfalfa and 100 per acre on the open prairie.

Cockerell (l. c.) says that they reached Boulder, Colorado, "about the 8th of May." List (1935) said that they appeared in many parts of the States on May 10th, that their activity was reduced by rainy weather in the middle of the month, but that up to the 23rd they were out in numbers whenever the sun appeared.

In Utah, according to Sugden (in litt.), large flocks appeared flying to the north on May 7th and 8th from the junction of Salt Lake and Utah counties south to Richmond, Utah. There was also a small flight over Salt Lake City.

Knowlton (1935) says that migrations were observed in Utah on numerous occasions in the first three weeks in May and even earlier.

In Idaho, on May 31st, Wakeland (1935) reported "The butterfly has been reported to be quite numerous in Teton Co. but is only fairly numerous now. I have noted them in flight as far north as Dubois County."

There has been no mention of *V. cardui* in the "Insect Pest Survey Bulletin" in 1936 or 1937.

DISCUSSION

The recorded flights and abundance of the Painted Lady in the four recent years of maximum invasion, 1924, 1926, 1931 and 1935, are shown in Figure 2. It will be seen that in the first three of these the invasion spread right across to the

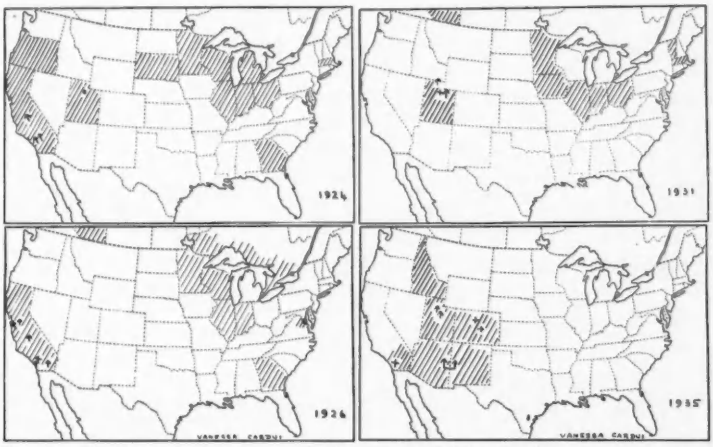

Fig. 2. Flights and abundance of *Vanessa cardui* in the four recent years of maximum invasion.

Atlantic States, but in 1935 it was apparently confined to an area in the Rocky Mountains. Undoubtedly many of the blank areas in these maps are due to lack of information, and any record that will help to complete them will be welcomed by the writer.

All the directional flights of the Painted Lady that have been recorded up to date, including those in my previous summary and those noted in the present paper are shown in Figure 3. It will be seen that the area where nearly all the flights have been recorded is in Southern California, with a few in Arizona, New Mexico, Colorado and Utah. The two records in the north-east are both old ones; in York County, Ontario, in 1865,

and in Minnesota in 1888. The record in the south of Florida is that of a visiting French Entomologist, M. Honore, who found himself one morning in May, 1916, when near Key West, suddenly surrounded by a great swarm of butterflies which as suddenly disappeared. No specimen was captured, but he considered the identification accurate as it was one of the few butterflies that he saw that was identical with the European species (Williams 1926).

So we find that the whole of the United States may be covered by invasions of *V. cardui*, right across to the Atlantic coast, but that there is practically no evidence of any immigration, except along the extreme south-west bordering on the western half of Mexico. There is not a single record of a mass flight in Texas, in spite of many records for other species.

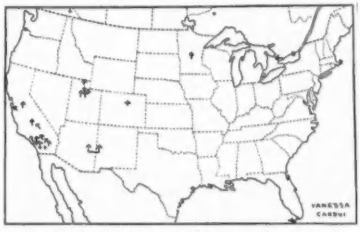

Fig. 3. All directional flights of *Vanessa cardui* noted up to date.

In Europe all our evidence on the origin of the migrating swarms of *V. cardui*, which spreads in a similar way over the whole of our continent, indicate that they come in the spring from the desert or semi-desert areas in North Africa. The origin of the North American immigrants appears to be somewhere around the similar arid zone in the S. W. States and Northwestern Mexico. If there is this definite connection between the source of the swarms and aridity, one would not expect any invasion to take place from the south through Florida. The butterfly is found in many of the West Indian Islands, but has never been recorded there in swarms.

Should this suggestion be correct, the problem then is whether the South Atlantic, and Gulf States get their Painted Lady butterflies from the invasions from Western Mexico; or if not, from where? The fact that Richards in Georgia and Clark in the District of Columbia found the species to be abundant in the same years that it was recorded invading in

swarms in Southern California and rare when there were no such records, lends considerable support to the view that the origin of the swarms is the same. Do the butterflies then, move across Texas and the Mississippi valley without being noticed? This is possible if the movement takes place in open order and not in compact bands, as the study of insect migration in the U. S. A. has not yet reached the stage when special observation is made to trace thin movements. At present the greater part of the information available is from accounts of flights which only by their intensity have forced themselves to the notice of the general public and the popular press. This emphasis on mass flights, if not recognized, may lead to a false idea of the prevalence and duration of any movement.

Ascia monuste (L.), The Great Southern White

In my previous summary about fifteen mass flights are recorded of which seven were in U. S. A., and the others in Jamaica, British Guiana, Uruguay and the Argentine. The records in U. S. A. were six in Florida and one in South Carolina, from the end of April to the beginning of June; five were towards the South and one towards the North.

Since this publication a number of new records have been made for Florida, which can be summarized as follows:

(1) 1930, mid-April to end of June. Indian River, Florida. To sonth. Heavy flight, much thinner towards the end, all going south agaiust the wind. Extended over 200 miles from North to South and continued for over a month, but during this period hardly one to be seen five miles west of the River. H. T. Fernald (1931).

(2) 1932, April to June. Titusville and Cocoa, Florida. To South. Less abundant flight than in 1930, first indication on April 4th. On June 15th autos came into Orlando with radiators covered. H. T. Fernald (in litt.).

(3) 1933, May 10. East Coast, Florida. To *North*. M. D. Leonard drove for several miles through a swarm on East coast about 50 miles south of Titusville and Cocoa. H. T. Fernald (in litt.).

(4) 1935, April. Merritt Island to Jacksonville, Florida. To South. J. M. Dewey writes that in this year he observed the largest flight he had ever seen. The butterflies travelled day and night, like a snowstorm. On some days on the banks of Indian River, the shoulders of the road were white with butterflies killed by passing cars. Very few were seen north of New Smyrna. They seemed to strike the road about 10 miles south of this town, and then were very numerous at least as far south as Melbourne (observer went no further). The flight lasted for about a month, flying usually 5–6 feet from the ground, seldom over 15–20 feet. Mr. Dewey writes: "My notion was that they came from the northwest to the place where they struck the coast section south of New Smyrna and then traveled south.

(5) 1935, April 20–24. Orlando, Florida. To Southwest. Fernald (1937a) states that he observed a small flight on this occasion, which was the only time he has heard of any flight direction other than to north or south, and also the only time he has known a definite flight away from the coast.

(6) 1936, May and June. Florida. H. T. Fernald (1936) records flights at New Smyrna on May 10th, going to the north; at Daytona Beach on May 19–24th, going north; and from Indian River City, south to Cocoa on June 4th, flying to south. He also states (1937a) that on one occasion this year (date not given) he saw them near New Smyrna coming out of a wood and flying from West to East.

(7) 1937, February to May. Florida. Chiefly to north. Fernald (1937c) writes that the flight under way on February 6th seems to have been checked by colder weather. It was noted again at Daytona Beach, going north, on April 10th; and still going north on April 24th at the same place. On May 1st a car came into Orlando with radiator covered with butterflies. On May 10th he drove from Orlando to Indian River City and then north to New Smyrna and saw no distinct flight, though a little north of New Smyrna this butterfly was abundant. What little movement there was was northward.

(8) 1937, May. Atlantic Beach, Florida. To north. Miss C. Reid writes that early in May large numbers of *A. monuste* were flying to the north on the beach and to about three blocks back. Not nearly so many as often seen at this time of year. "They are always flying to the North."

(9) 1937, May 24th–beginning of August. Melbourne, Florida. To South. Mr. and Mrs. K. Hodges report to me that beginning about noon on May 24th there was a thin flight of *A. monuste* going directly to south. Bright clear day, temperature about 80° F., wind northeast; speed 5–10 m. p. h.; flying 5–10 feet from the ground. On two days during this period, namely, July 5th and 6th, the flight was, however, noted to be towards the north. The same species had been noted regularly in previous years. This year fewer than usual. Specimens sent to me included 11 males and 16 females, the latter all of the grey form (*philea*). A few small yellow butterflies (*Terias lisa*) were included in the flight.

(10) L. M. Dewey writes that in Florida the Mangroves bloom usually in August, and at that time you can see the same butterfly lazily feeding from tree to tree, but its flight is then northward, but very slow. This has been noted very near the coast some distance East of the Indian River, the west bank of which seems to be the main flight route during the southern flight.

The above information makes it appear that the flights in Florida start rather earlier than was previously suggested, and also indicate the possibility of a return flight later in the year.

Considering the Spring flight only it must be noted that many of the Florida flights are towards the north and others towards the south.

H. F. Fernald (1937a) has made the suggestion that the flights originate somewhere to the west of New Smyrna and

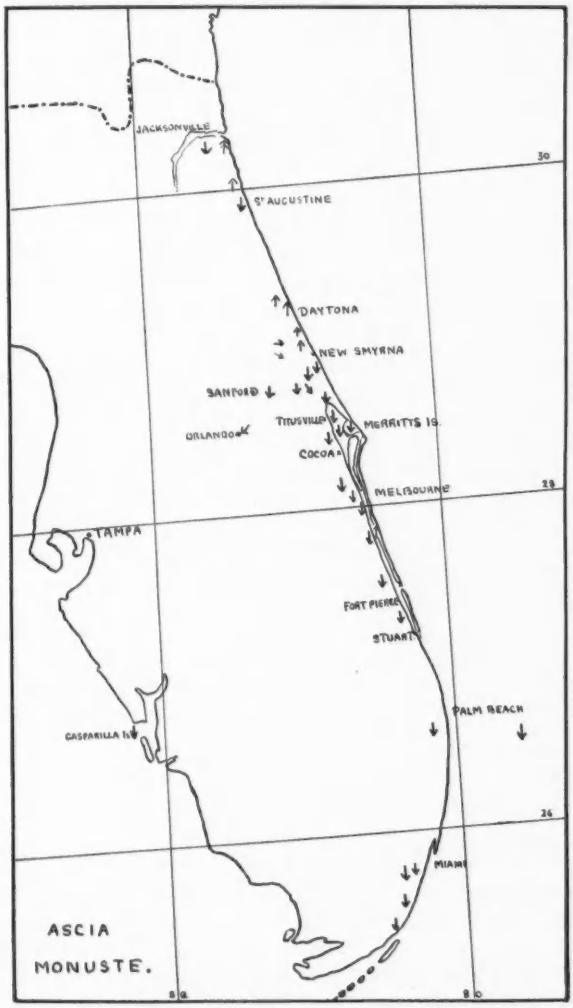

Fig. 4. All flights of *Ascia monuste* recorded for the State of Florida.

after flying east to the Coast the butterflies divide up into two streams, one going to the north past Daytona and Jacksonville

and perhaps to Georgia and South Carolina; and the second stream going south down the Indian River and continuing perhaps along the Keys to Cuba or out to sea in a south-east direction as suggested by observation of Stirling and of Ball and Stone.

Figure 4 shows a map of Florida on which all the recorded flights have been marked by arrows and it will be seen that on the whole it gives considerable support to Fernald's theory. The theory is also supported by the remarks of Dewey quoted above, who came independently to the same conclusion as to the possible area of origin, and also to the limited extent by Ball and Stone (1928) who recorded that during the southward flight near the coast the direction of flight became south-east or east inland from the sea just south of New Smyrna. However, still further inland near Sanford it was again southerly but very thin.

On the other hand there are one or two flights recorded that do not fit into this scheme. Such as for example the full records of Ball and Stone (1928) who reported a southerly flight at Jacksonville and St. Augustine on May 10, 1928, gradually moving south to New Smyrna and Fort Pierre by May 20th and extending as far south as Miami by June 20th.

It should be noted that all the Florida records are on the east Coast except that of Mr. Lowe who saw them passing south at Gasparilla Island at the mouth of Charlotte Harbor in April, 1906.

As a possible indication of migration in another part of the United States I may put on record that at the end of August, 1928, Mr. R. A. Gottholt captured four or five specimens of both sexes at Morfa, Texas, which were the only specimens seen in years of collecting.

In Virginia according to Clark (1937) it is only known from the coastal region as a summer visitor.

Phoebis eubule (L.), The Migratory Sulphur

In my summary in 1930 this species was shown to be a regular migrant throughout the greater part of the American continent, and about 25 records of flights were given for the United States, nine from Tropical Central and South America and the West Indies, and four from the Argentine. The latter were all in March and April, which is the autumn in that part of the world, and towards the north, or towards the equator.

The records in the United States were with one exception flights more or less to the south in the autumn; the exception being a record of a flight to the northwest in Georgia in March.

Since the above has been written a number of new records in U. S. A. have come to hand, including in particular a remarkable series of observations made by Mr. P. H. Smyth in Montgomery, Alabama, over eighteen consecutive years.

Figure 5 shows a summary of Mr. Smyth's observations from August 5, 1920, to July 15, 1937.

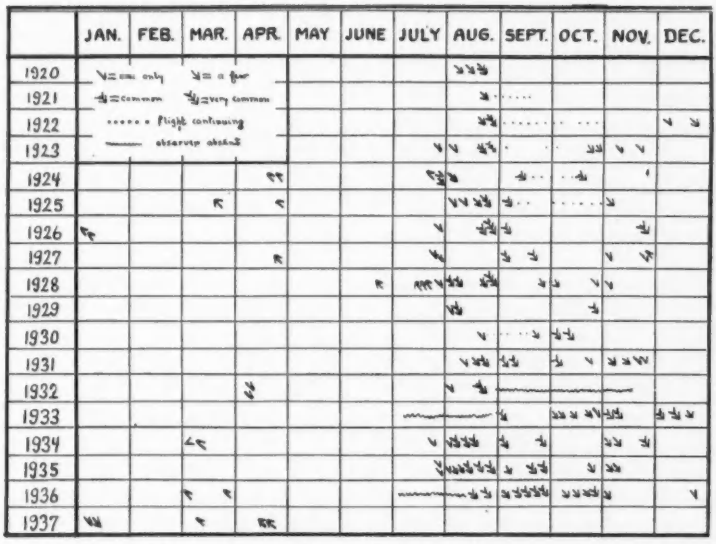

Fig. 5. Mr. P. H. Smyth's records of *Phoebis eubule* over a period of eighteen years at Montgomery, Alabama.

It will be seen that there is in this area an absolutely regular movement of *Phoebis eubule* towards the southeast starting about the end of July or beginning of August and continuing regularly till the beginning of November, while in some years a few stragglers persist well into December, and during the winter of 1936–37 even into January.

The flight was usually quite thin and only on a few occasions were large numbers seen. Thus on August 28, 1923, he reports them as "very numerous;" on August 31, 1926, "more numerous today than at any time so far," and on August 31,

1938, "more numerous than I have ever before seen them. Radiators of automobiles coming in from open places were literally covered with yellow butterflies."

In the spring, on the other hand, in March and April occasional individuals are seen moving in the opposite direction towards the northwest. This was observed in six years.

In 1928 a few butterflies were seen going to the northwest as late as July, just a few days before the start of the main southeast flight; and in 1932 two butterflies were seen flying to the southeast in April.

In spite of the few small exceptions the observations demonstrate beyond all doubt a spring migration (March and April) of this species in Alabama towards the northwest in small numbers, and a much larger migration towards the southeast in late summer and autumn.

In addition to the above there are the following new records:

Alabama. (1) Mr. L. B. Robertson reports that in 1896 at Healing Springs, 60 miles from Mobile, he saw a definite flight of light yellow butterflies all individually going towards the East.

(2) Col. G. R. Catts reports that about September 10th, 1935, at Verbena, Chilton County, Alabama, there was a flight of yellow butterflies towards the East. Always 1–10 in view in a small pasture about 100 yards wide, flying 3–10 feet from the ground, and direction possibly a little south of due east.

Mississippi. Mr. R. S. Smith reports that every fall at Biloxi there is a definite movement of yellow butterflies from west to east, continuing for several weeks and generally 2–3 individuals in sight at any one time. About 3 miles away from the point of observation the butterflies have to cross a mile or more of salt water in Biloxi Bay. In 1937 Mr. Smith reported that one or two were seen going to the east as early as June 30th and on the following day (July 1st) the movement was quite distinct.

Missouri. In Missouri, Brower (1930) reports a regular migration to the southeast in August, September and October; and O'Byrne (1933) records a steady flight in St. Louis County from September 3rd to early October, 1932, going to a few degrees east of south. The flight averaged about 147 individuals per hour on a 100 foot front; most numerous 10:00 A. M.–3:00 P. M.; 2–10 feet above the ground; direction independent of the wind which varied from west to northwest.

Kansas. Calkins (1932) reports that this butterfly is not common but can usually be taken in September.

Virginia. Dr. A. H. Clark writes to me that this butterfly "appears every summer, and by the end of the season, has covered practically the entire state. It appears to enter the state by three different routes. (1) Coming up along the coast and up Chesapeake Bay, (2) coming north along the eastern foothills of the mountains, and (3) coming up the

valleys of the streams belonging to the Mississippi Valley watershed. The females oviposit on arrival so that the increase is very rapid."

Dr. Clark has seen directional flights of the butterfly many times both in Virginia and the District of Columbia, always more or less towards the East. He sends the following examples:

(1) 1933, September 24th; Nottoway County, Va., frequent, all flying to the southeast.

(2) 1935, August 31st; Hanover County, Va., a few flying to west.

(3) 1937, August 11th and 12th; Augusta and Nelson Counties, Va., flying to the northeast.

Tennessee. Mr. H. B. Walker, of McMinville, Tennessee, writes (to Dr. A. H. Clark) that *C. eubule* "moves most of the time in a zigzag manner; it is always moving from the northwest towards the southeast, and can be seen constantly in this region the last of August and the first of September. The mountain people call them the Travelling Butterfly."

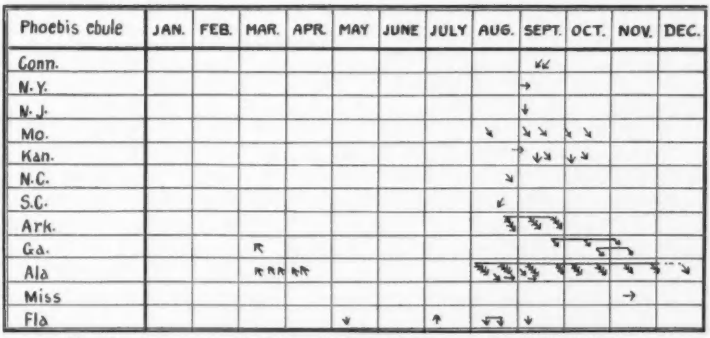

Fig. 6. Summary of flights of *Phoebis eubule* in the United States.

Florida. G. B. Merrill (1936) reports a considerable southward flight on Lake Santa Fe near Waldo, Florida, during the week beginning September 5, 1936.

Mr. Hodges reports that at Melbourne, Florida, specimens of *Phoebis eubule* joined in the *southward* flight of *P. monuste* in May, 1937; that they were migrating to the north on July 5th and 6th again in company with *P. monuste*; and that during August and September, 1937, nearly every day they were noted, the general direction of movement being southwards. Specimens were sent from all three migrations, the directions of which are distinctly confusing.

Texas. Mr. E. R. Tinkham informs me that in two successive years this butterfly appeared suddenly in small numbers at Presidio, on the Rio Grande, in 1928 on September 28th, and in 1929 on September 29th, indicating the possibility of immigration.

California. Mr. Doudoroff writes to me (July 5, 1937), "perhaps also of interest might be the apparent infiltration of *Phoebis eubule*

into more and more northern regions of California. About six years ago I noticed freshly emerged males and females in Pacific Grove. In the last two or three years specimens have turned up about Palo Alto (34 miles south of San Francisco) in greater and greater numbers."

Minnesota. A male (now in collection of the University) was captured by G. Holgate at Itaska Park, Minnesota, on July 18, 1930.

Figure 6 shows in diagrammatic form all the information at present available about the movements of *Phoebis eubule.* It would appear that the butterfly spreads far to the north in eastern and central U. S. A. and that the autumn southward flight east of the Mississippi converges towards Florida. Further west than this there is quite insufficient evidence to draw any conclusions. It would be most interesting to know if there is any evidence of the survival of this butterfly throughout the winter anywhere in U. S. A. Further information is also needed on the extreme limits of its northward spread.

Kricogonia lyside Godart, The Lyside

In my previous review only two records of flights of this species were quoted, one from Jamaica and the Cayman Islands in 1891 and one from Haiti in 1926.

Aaron (1929) states in the Rio Grande District of Texas it occurs in small numbers in the hot periods of the spring rainy season and summer droughts. At or near the end of the dry season, about September, the prairies, from the Guadeloupe valley south, teem with countless numbers all flying north to south, many going far into Mexico. After that they are generally common in the district. Another flight takes place in April or early May in vastly reduced numbers to the north. The autumn flight, as seen by Aaron, was "close to the ground and as high in the air as the eye could detect."

The spring flight is confirmed by two other records, one by Dawson (Williams 1935) who saw large numbers on the neighborhood of Artesia Wells, Texas, on March 24, 1933, flying to northwest. The wind moderate to light southeast, bright sun and temperature about 90° F. The insects were flying low about two feet from the ground.

On the other hand a record recently received from J. R. Hansworth reports that millions were seen on May 10, 1937, between Monterey, Mexico, and Wharton, Texas, flying to the east or southeast against the wind. They were flying about 2–3 feet from the ground.

E. R. Tinkham informs me that the species was common in the Chisos Mountains, near Presido, Texas, on July 16–17, 1930, but without any definite movement.

Calkins (1932) reports that in Scott County, West Kansas, only about half a dozen specimens had been recorded, all in early spring flitting around apple blossom. In the summer of 1931, however, the butterflies were quite common in alfalfa fields, the females outnumbering the males, but perfect specimens were difficult to obtain.

According to Holland the species occurs also in Florida, but we have no records of migration from there. A close watch should be kept to see that it is not confused in flight with *Phoebis eubule.*

Eugonia (Aglais) j-album Boisd. and Lec., The Compton Tortoise

In my previous review there are given three old statements, none since 1880, indicating that this species might migrate; but no record of directional movement. The most definite of these three was Scudders note (1874) that the species had appeared in great numbers at the Sankaty Light-house, Nantucket, on September 11, 1874, although never seen in the district before.

Mr. B. Preston Clark has now informed me that he saw a definite movement of this species in the Ice River Valley, Alberta, in early September, 1905. They were flying towards the south at an elevation of about 7,000 feet. They were first seen about 10 A. M. on a warm sunny day, several flying down the valley 3–4 feet above the ground. All the way up the valley the steady stream was noticed and when the glacier was reached by the observer, the butterflies were seen to be flying over the surface of the glacier and only a few feet above it. On the return journey the same thing was noticed and the flight continued every day almost to sunset for about a week. Mr. Clark estimated the numbers as at the very least 700 per day or 4,000 for the week down the one valley. At the end of the week the temperature suddenly dropped to below freezing and the camp was abandoned. Mr. Clark considers that the flight was a vertical migration from Alpine meadows at 10,000 feet or more down to 4,000–5,000 feet when they could hibernate in safety.

Eurema (Terias) lisa (Boisd. and Lec.), The Little Sulphur

This small yellow butterfly was included as a migrant in my previous summary on the strength of four records of its arrival

in great numbers in the Bermuda Islands from over the sea; on October 10, 1847; on October 1, 1874; in 1909, and on October 21, 1927. It will be noted that all the three records in which the month is stated are in October. It was assumed that the insect had come from the mainland of North America, but there was no record of a directional movement there.

Recently Mr. and Mrs. Thos. K. Hodges have sent me a number of specimens of this butterfly taken along with many *Pieris monuste*, in a thin flight towards the south at Melbourne, Florida, on May 24, 1937. The flight started about noon on a bright clear day with temperature about 80° and wind northeast, the level of the flight was about 5–10 feet from the ground, and the Terias stopped at times to feed. Next day only a few stragglers were seen. In a later letter Mr. Hodges states that the *Terias lisa* continued to be common in the district up to the middle of September, but then became rarer.

Dr. A. H. Clark says that in Virginia this species is everywhere one of the commonest butterflies in the late summer, but that there are very few spring records. He does not yet know if the millions of individuals in late summer are descendants of the very few that have overwintered, or of immigrants from the South.

Vanessa californica Boisduval, The Californian Tortoiseshell

In my previous summary eight flights are recorded in British Columbia, Oregon and California, and also a great outbreak of caterpillars in Idaho. The flights were nearly all in August and September with one as late as November (in San Francisco in 1856).

Since then a number of new records have been published and have come to hand which can be summarized as follows:

(1) 1918, September 13th. Yakima, Washington State; flying to west. Frank Bryant reported a vast migratory swarm, 3–4 miles wide and filling the air as high as the eye could see passed over Swank Valley in Killitas for several days, going due west. A number had been noted flying on August 18th.

(2) 1922, August 9th. Tahoe, California; flying to north. Mr. J. A. Comstock (1927, p. 124) reports that there was a continuous flight of this species at Trachee near Tahoe for three days throughout all daylight hours. More than fifty butterflies were taken with one sweep of the net. The date was not given in the original but was kindly sent to me by Mr. Comstock.

(3) 1926, on Mount Shasta, California; swarmed on a sunny day, air filled with thousands sweeping down the mountain. Not seen above 8,000 foot level. Hewes (1936).

(4) 1930, August. Crater Lake, Oregon; flying towards the north. Extensive flight observed by K. M. Fender on August 15th and 16th, from about noon each day to nearly 6 P. M. at an altitude of about 11,000 feet, 4–6 feet from the ground. Females seemed to be slightly in excess but no mating or ovipositing was seen. (O'Byrne 1932).

According to information received from Mrs. A. M. Veazie this flight was also seen by another observer on August 14th.

(5) 1931, April 25th. Ventura Co., California.

According to a letter from J. A. Comstock a large migration of this species was seen in the neighborhood of Warners Hot Springs, but the direction was not noted.

(6) 1931, July and August. California; flying to west.

About July 1st millions of caterpillars and chrysalides on "snow bush" on Mount Shasta. Adults in full flight by mid-July. Millions flying about 150 feet up among tree tops so thick as to dim the sunlight. After an hour came down to about 6 inches to 5 feet above ground, started off about 6:30 A. M. on July 18th; 600 were caught in 1½ hours. Six days later still flying at top of Mount Shasta at 14,000 feet, stopped on the snow to drink. About a month later stragglers still flying westward (Martin 1932).

(7) 1931, July. Cascade Mountains, Oregon.

According to a report from Mrs. A. M. Veazie flights were noted this year on July 13th on "Three Sisters" and "Mount Washington," and on July 30th on "Mount Wagner" and "Dutchman's Peak." The direction of flight was not recorded.

(8) 1932, March 6th. Point Arena, California; flying to north and west. E. O. Essig (1932a) reports "a definite migration of the Californian Tortoiseshell from 1–3 P. M."

(9) 1932, May–August. California.

According to various reports there were extensive movements of this species during 1932. Essig (1932 b and c) reports that from mid-May to June caterpillars were abundant on Western foothills and slopes of Sierra Nevadas from Eldorado in the South to Butte in the North, and from 2,000 to 7,500 feet in the neighborhood of Lake Tahoe. Caterpillars first noted mid-May; on June 4th, 100 acres defoliated in Butte Co. On June 8th countless adults were emerging in Eldorado and moving out to high altitudes, flying up the American River Canyon to above the limits of the melting snow. In early July caterpillars of the second brood were feeding at 7,500 feet and adults of the second brood appeared at the end of July and beginning of August, especially in the Lake Tahoe region. The gradual dispersal from the high altitudes to low altitudes caused considerable comment in the press.

(10) 1932, June 19th. Alpine Highway, California; flying to north. In confirmation of the above, D. B. Mackie reports that in 1932, at Alpine Highway, near Mud Springs, California, at an altitude of about 8,000 feet great numbers were flying to the north from 10:30–11 A. M., going very fast 10–20 feet from the ground. The observer passed through the flight for several miles but only at one point was it really dense.

(11) 1932, July. Oregon.

On July 13th millions were said to be flitting around Three Sisters Mountain at about 10,000 foot level by newspapers (Martin 1932). On July 24th Mr. and Mrs. Gilbert Grosvenor reported such millions on Crater Lake, flying to the south that their car had to be stopped every few minutes to clear the windscreen. On the following day they saw countless numbers crossing the Crater River at about 8,000 feet from north to south (Williams 1937). On July 26th the same flight was observed by Dr. Norman (Williams 1935) in Garfield Park about 11:30 A. M. at an altitude of about 8,000 feet, crossing a quarter mile front in enormous numbers. They were seen flying towards the S. S. E. and coming in across the lake for at least three-quarters of an hour. The day was brilliant sunshine and the temperature about 85° F. On July 30th, according to a report from Mrs. A. M. Veazie "the flight which began several days ago was still continuing and butterflies were filling the air."

(12) 1932, late August. Mount Lassen, California. Flying to east. Mr. A. E. Vinson reports to me that he saw a great migration of small brownish butterflies late in the afternoon towards the end of August flying towards the east, when on Mount Lassen. The butterflies did not change their course to avoid the summit which is 10,200 feet, and many were stranded on the snow banks of the extreme summit.

(13) 1935, July or August. Nicola Valley, British Columbia; flying to north-west. Mr. E. R. Buckell reports that there was a migration of this species in the cattle range country at an elevation of about 3,000 feet flying to the north-west.

The above records considerably extend our knowledge on the migrations of this species. The area where movements occur is now known to include Washington State, but the most interesting new information is undoubted the two records of flights in the spring months, March and April, in California (Nos. 5 and 8). In addition to the above I have a report of a big immigration into Alberta* about 1919, but so far have not been able to get any exact information.

Pieris rapae (L.), The Cabbage-butterfly

The small cabbage white butterfly (*Pieris rapae*) was accidentally introduced into Quebec, Canada, from Europe, in 1858, and spread rapidly throughout North America, reaching California about twenty-five years later. It has thus been established in the eastern half of the continent about eighty years and in the Western States just over fifty years.

In Europe the butterfly is a regular migrant and its move-

*Since the above was on the press I have heard from Mr. D. Mackie that the invasion was in 1918. First arrivals in Edmonton on August 25th; Maximum about September. 3rd One taken as late as October. 3rd Reported 100 miles north of Edmonton.

ments (usually in association with the larger *Pieris brassicae*) have been known for nearly a hundred years.

It is therefore of particular interest to see to what extent this butterfly will develop its migratory habit in its new home and what directions or routes, if any, these movements will take.

At the moment the evidence is very scanty indeed but it is summarized here, only to show how much more information is needed.

In my previous review (1930) only one North American record of mass migration was recorded, Shannon (1917) having noted it as occasional in a large migration of Monarch Butterflies at Long Beach, Long Island, in September, 1916, flying usually towards the west.

I had at that time overlooked two records: the first by Andrews (1919) who stated that on August 12, 1918, a huge swarm was seen coming inland from off Lake Ontario at Kew Beach near Toronto and flying to the N. N. E. with a gentle S. S. W. wind.

They were first seen about 11:30 A. M. over the lake, and for three or four days afterwards they were a perfect pest to people walking on the beach. With them were the largest number of dragonflies the observer had ever seen.

The second is by Fenton (1919) who recorded that many *Pieris rapae* and some *Colias philodice* were flying to the southeast along with large numbers of Monarchs on September 16, 1916, at Charles City, Iowa. He found all three resting together for the night.

In the spring of 1928, according to a report that I have received from Mr. E. Jaeger, there was a "heavy passage" of Cabbage White butterflies from southwest to northeast in California. It was rather local in character and apparently confined to the Persis Valley.

At the beginning of May, 1935, according to a letter from Mr. J. W. Sugden there was a great flight in Salt Lake City, Utah, in such numbers that they were described as having the appearance of "falling snow."

Mr. V. M. Cutter, Jr., writes to me that from August 30 to September 2, 1927, he saw a definite movement of this butterfly at New London, New Hampshire, the direction of flight being due east. The migration only seemed to occur on a track about 3 miles wide and Mr. Cutter was unable to locate either the source or terminus of the flight. During the greater

part of the flight the prevailing winds were from the southeast. No other species were associated with the *P. rapae*. An estimate of the numbers passing, was that "looking across a body of water roughly one mile across during the migration, not more than 50 individuals could at any time be seen. This number was, however, fairly consistent over the whole migration." The weather was fair with an average maximum temperature of about 75° F. No unusual numbers of *P. rapae* had been noted in the district previous to the movement.

Mr. Cutter makes the interesting observation that at 4:00 A. M., on the morning of September 1st, when it was still dark, the butterflies were on the move, and he suggests that they had continued flying during the night. No previous evidence that a Pierid butterfly migrates throughout the night has yet been brought forward, but the Nymphaline *Eugonia j-album* has been recorded as suddenly appearing in great numbers at night at the Sankaty Lighthouse, Nantucket, and in our investigations of the migrant butterflies of Europe we have distinct evidence of night flights of *Vanessa atalanta*, and *Vanessa cardui*.

On September 30, 1937, at Holtsville, Long Island, Mr. E. Freel noted a flight of small white butterflies traveling towards the southwest between 2:15 and 2:45 P. M. They were about 20 feet above the ground traveling fairly slowly. The day was sunny and fairly warm. The wind was N. W. I think that there is little doubt that the species concerned was *P. rapae*.

Libythea bachmanni Kirtland, The Snout-butterfly

In my previous summary this species was known as a migrant from ten records of mass flights, all in Texas. There was, however, a record of an unusual appearance in numbers in Indiana and single specimens in Ontario, Canada. Of the recorded flights in Texas all except two were to the S. E. quarter; the two exceptions being towards the north.

The following new information is now available.

(1) Near Jonesborough, Illinois, in June, 1862, the species suddenly appeared in swarms (Edwards 1884).

(2) In Racine Co., Wisconsin, it was common in 1875. (Scudder 1889.)

(3) At Mitchell, Scotts Bluff Co., Nebraska, the species was found by Mr. R. W. Dawson on August 20, 1916, in hundreds, all going the same direction. They were flying within two feet of the ground, most somewhat worn. Bright sunny day. Mr. Dawson had only twice before

captured the species in West Nebraska, one individual on July 5, 1908, and one on September 19, 1914. (Williams 1933.)

(4) At Little Rock, Los Angeles Co., California, on October 27, 1929, Mr. Friday came across a migration of this butterfly from which 25 males and 20 females were captured. Up to that time the butterfly was quite a rarity. The date in the original account (Gunder 1930) is given as 1930 by mistake.

(5) In the Chisos Mountains, near the Rio Grande, Texas, on July 16 and 17, 1930, Mr. E. R. Tinkham found the species in countless thousands but not actually on migration.

(6) In the Lower Rio Grande Valley, Texas, on July 18, 1932, Mr. O. H. Clark found great numbers in rapid flight towards the N. E. The great majority were 3–5 feet up but some as high as 15 feet. The flight was followed from Harlingen, Texas, through Laredo to about 30

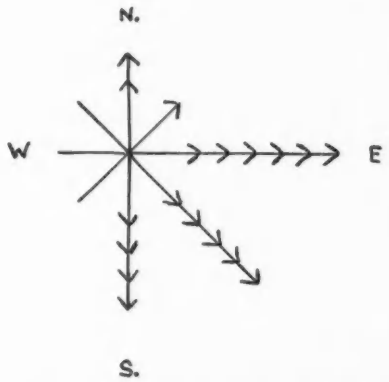

Fig. 7. All flight records of *Libythea bachmanni* for the State of Texas, which indicates a preponderance of direction towards the south, southeast and east.

miles south of Laredo on the Monterey Highway, when the flight tapered off. Several hundreds were continually visible from car windows.

(7) Mr. O. H. Clark saw a second flight near Harlingen, Texas, about two months later, from September 9 to 15, 1932. It was similar in density to the July flight and was moving to about 5° north of east. Two hundred butterflies passed per minute on a 100-foot front. No effort was made by the butterflies to avoid obstacles by deviating to the right or left, but they would rise vertically till the top was reached and then continue in the line of flight.

(8) In July, 1937, there seems to have been a large movement of this butterfly in Texas of which I have received three separate records:

(a) Mr. R. S. Guinn saw the flight on July 5, 1937, between Alice and Kingsville, Texas, going to the south. It extended for at least 14 miles and was chiefly noted when the observer was driving east about 14 miles south of Alice at 2 P. M. There were vast hordes of the butterflies. The same swarms were again seen about 4:30 P. M. when the

observer was returning, and another was seen between Robstown and Corpus Christi. Mr. Guinn sent me two specimens both of which were *L. bachmanni.*

(b) Mrs. Bruce Hannah saw hundreds of butterflies flying towards the south at Corpus Christi, Texas, from 9–10 A. M. on July 26, 1937, and for a shorter period on the following day. They were flying fast about 10 feet above the ground on a sultry day with practically no wind. Five specimens were sent, all *L. bachmanni*, but Mrs. Hannah stated that some yellow and some white butterflies were seen along with the brown ones.

(c) Col. G. R. Catts reported that shortly before July 30th some military motor lorries ran through great numbers of brown butterflies all flying to the east in the San Antonio district of Texas. An occasional yellow butterfly was among them. The remains of four butterflies, scraped off the motor radiators were sent to me and all were *L. bachmanni.*

The new records show definite movements to have occurred in Nebraska and Southern California, and sudden appearances in Illinois and Wisconsin, in addition to the regular movements in Texas. In the latter State the records are all between the end of June and the beginning of October. Fig. 7 shows the recorded directions of flights in Texas which indicates a preponderance toward the south to east quarter and no records with any westerly component.

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REARING THE COCCINELLID HIPPODAMIA CONVERGENS GUER. ON FROZEN APHIDS

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The ladybeetle *Hippodamia convergens* Guer. cannot be handled in the laboratory in quantity unless there is available at all times an abundance of aphid material for food. Field populations of aphids can be relied on only at intervals during the year. In the search for an all-year-around food, it was decided to determine the feasibility of freezing and storing aphids, collected during periods of abundance, for use during remaining parts of the year. The work was prompted by the need of an unfailing *convergens* egg supply for ovicide tests (2).

The first aphids were frozen in June, 1935. By the following fall it was noted that methods could be developed for freezing and storing them at subzero temperatures (C.) without loss of body fluids through dessication. Also it was evident that satisfactory egg production by *convergens* could be maintained at any time of the year on frozen aphids, but that very special methods and equipment would have to be used.

This equipment was developed (1). During the studies, attention was given almost exclusively to the production of eggs by adults. Larvae can be reared through to adults that produce fertile eggs. However, methods have not been studied for bringing them through in quantity. Frozen aphids proved especially valuable to the writer as food for first instar larvae during larval insecticide tests (2), at a time when field aphid populations failed. Furthermore, the dead, motionless, frozen aphids were much easier to handle than living, mobile forms.

METHODS

Species of Aphids Frozen. Species frozen in large quantity include the poplar gall aphid (*Pemphigus populi-transversus*, the false cabbage aphid (*Rhopalosiphum pseudobrassicae*), the pea aphid (*Illinoia pisi*), and the giant hickory aphid from sycamore (*Longistigma caryae*). Also, the aphid from willow (*Clavigerus smithiae*) and the bean aphid (*Aphis rumicis*) were frozen with success.

[1]The author wishes to express his appreciation to Dr. Alvah Peterson, under whose direction this work was done, and to Dr. Harold A. Waters, for many helpful suggestions.

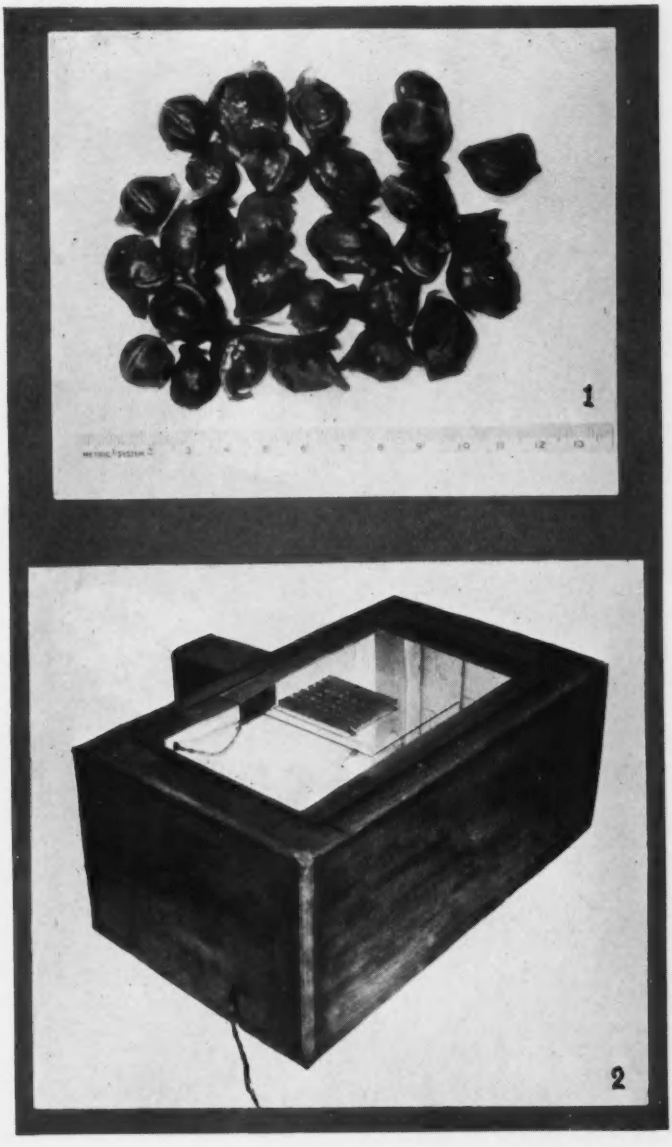

Fig. 1. Poplar galls (*Pemphigus populi-transversus*), prepared for freezing.
Fig. 2. Coccinellid cage in place on light-box.

Most of the above species have been in storage since October, 1935, and there is no apparent change in their condition.

Of all species experimented with, the poplar gall aphid has been the most satisfactory. On removal from a cold environment it decomposes and dessicates less rapidly than the other species, especially the pea aphid. This factor is very important.

Freezing Methods. Aphids are packed in air-tight glass containers and stored at —21 to —25 degrees C. Probably higher temperatures, yet below 0 degrees C., would be satisfactory. Rubber-stoppered shell vials, 22x65 mm., pint and quart wide-mouth fruit jars are used. Cellucotton saturated with water is placed in the top of the container to increase humidity before freezing.

Poplar galls are trimmed from the leaf petiole (fig. 1) and packed, about 260 per quart. Non-gall forms are packed loosely in the container.

Apparatus for Feeding Frozen Aphids to Convergens Adults. Flowerpot saucers, petri dishes, pill boxes with transparent bottoms for use with light from below, and other cages of a similar nature cannot be used for feeding frozen aphids to *convergens* adults. In the case of a petri dish, egg production is low, and eggs produced are eaten. In a petri dish, adults cling to one another several deep, do little stirring around. Though there is plenty of fresh (frozen) aphid material about them for several hours after it is introduced, the adults each may feed on only one or two aphids, this at the time they are disturbed when the aphids are being introduced into the cage.

Beetles must be separated from one another, and kept close to their food supply through the proper use of light. The aluminum, cellular cage described below (fig. 3) was developed. It has proved very satisfactory and is standard equipment in this work.

Description of Feeding and Oviposition Cage. It is made of ½ inch aluminum stripping, and consists of 70 cells, 10 long by 7 wide (fig. 3). Each cell is ⅝x¾x½ inch deep, the whole thing is 5½x6½x½ inch deep. The layer of cells is closed-in on the bottom side by 8-mesh hardware (metal) cloth. The top of the cage is a sheet of glass twice the area of the unit of cells. In the center of this plate a ¾ inch hole is bored. By sliding the plate glass, access may be had through the hole to any cell for removing eggs, without exposing any other cell. When not in use a small square of glass is placed over the hole, to prevent beetle escape. Four metal clamps, one in each corner, hold the cage tightly down on to a sheet of glass the same area as the unit of cells.

The clamps slide off or on into place easily. Frozen aphids are sprinkled lightly on this bottom glass piece, the cage is then clamped to it and the beetles (one per cell) feed on the aphids through the wire screen. The beetles are positively phototropic. Constant light from below keeps them close to the food.

The beetles are fed twice daily. At each feeding the bottom glass piece is washed with water before fresh (frozen) aphids are spread on it. The metal part of the cage is cleaned every two weeks by removing the beetles from it and washing it in hot paraffin.

Most of the egg clusters are deposited on the sides of the cells. They

are removed from a surface with a camel's hair brush and water, the adhesive material being soluble in water.

To keep the beetles next to their food supply, all light is directed from below. So that light used in this work would not affect other experiments in the same laboratory, a special light box was constructed. It has been used in all feeding work, whether living or frozen aphids were used as food.

Description of Light-box. It is a cardboard carton 21x35x15¼ inches. A wooden framework inside gives it support. An opening is cut in the top leaving a margin of 4 inches, and this opening is covered by a sheet of heavy plate glass. Feeding cages rest on this plate glass, and are furnished with light from below. To prevent heat accumulation from the source of light, a tin can is set off on the side of the box. Inside this tin the bulb is mounted (five watts). Most of the heat generated by the bulb is radiated off by the tin, there is no accumulation in the box. Figure 2 shows a frozen aphid feeding cage in place on the light-box.

Beetles become too active when they are disturbed at time of feeding, or when eggs are being removed. An extra light (60 watts) is turned on, therefore, during periods of examination. This extra light on the bottom of the box effectively keeps the beetles in the bottom of their cells.

Description of Humidifier. Frozen aphids dry out too rapidly at ordinary room humidity. The humidifier developed for this work is shown in position over the feeding cage on the light-box (fig. 4). The humidifier has been also a necessary part of the technique employed when living aphids are used as food.

It is a box 17½x18x5½ inches deep made of ¾ inch redwood, heavily impregnated with paraffin. It is open at the bottom, and covered across the top with canton cloth. In each of two opposite corners is strapped a jelly glass containing a saturated salt solution.

In the usual laboratory, where the air humidity is low, K_2SO_4 is used. If the humidity is high in the room, the K_2SO_4 may have to be replaced by NaCl.

From each of the two glasses a wick of cellu-cotton leads upward, through a hole in the cloth to the top of it, and diagonally across. At right angles to this strip another strip of cellu-cotton is placed on the cloth, reaching toward the other two corners. By capillary action these strips are kept saturated with salt solution, which in turn is fed to the tight cloth top. The tightly woven face of the canton cloth is downward, the loose fluffy surface upward. Spread of the salt solution is on the under surface where the humidity is wanted. The loose fluffy surface on the upper side remains dry, greatly reduces evaporation upward, outside of the humidifier. To further reduce evaporation upward, a paraffined piece of thin composition board, 18x19 inches is placed over it. This cover is not shown in the figure.

The two jelly glasses containing the salt solution should be paraffined to prevent the salt from "creeping" over the edges. The jelly glasses are refilled with salt solution through the holes above them, through which the cellu-cotton wick passes upward. The holes are covered by small flaps of canton cloth, which can be drawn back as desired.

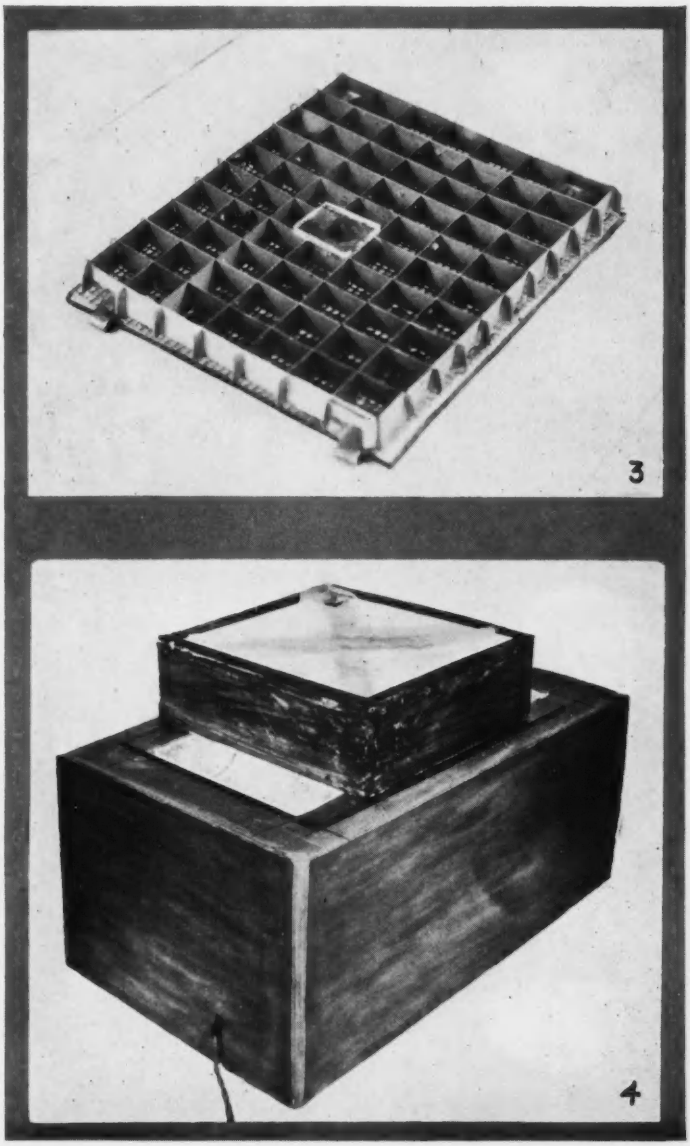

Fig. 3. Cage for coccinellids while feeding on frozen aphids and while ovipositing.
Fig. 4. Humidifier in place over feeding cage on light-box.

OVIPOSITION DATA

Two experiments are reported on. In each case, nothing but the frozen poplar gall aphid (*P. populi-transversus*) was used as food.

Using Old Adults. In the first experiment, complete egg records were kept for the winter period December 10, 1935, to March 12, 1936. The beetles used were old adults from California and Idaho with reduced egg-laying potentialities due to transportation, storage, and having already passed through a portion of their egg-laying activities. The California adults were first generation beetles that had gone into the mountains in June. They were collected July 4 in Placerville, had been kept in storage since that time. The Idaho adults were collected in December at Moscow. The latter were very inactive and weakened by a delay during shipment.

A total of 16,058 eggs was collected for the period. For the 94 days this averaged 170.8 eggs per day. A maximum of 525 eggs was collected on February 13. Altogether 241 beetles were used in the experiment. The number being fed each day varied. The average was 47, the maximum 66. Until the end of February the minimum was 17.

Only 92 beetles, or 38.2 per cent of the total, oviposited. Two factors account for this low proportion of producing females. First, they were old beetles, the Idaho individuals in particular, being extremely docile. But far more important than the age or previous history of the beetles, is the fact that they were kept on a semi-starvation diet during this experiment. At each feeding they were given a minimum amount of food. On 39 of the 94 days they were fed only once, and on 2 days not at all.

For maximum egg production beetles must be given an excess of food at least twice per day. Despite the starvation diet, however, female 49 deposited 898 eggs, female 40 deposited 882. Like several other individuals, female 40 was already laying eggs when records were begun December 10. Female 49 was not dead when the experiment was terminated.

Using Newly-emerged Adults. Twelve newly-emerged females were exposed to fertilization by 12 newly-emerged male beetles. All had developed from larvae that had been fed nothing but frozen poplar gall aphids. After fertilization the males were discarded, and the females fed frozen poplar gall aphids twice daily. The first 8 days of egg production was recorded.

Each of the 12 females produced eggs that hatched into normal larvae. Egg production was very gratifying. Though all beetles did not begin laying until the fifth day, 631 eggs were collected, averaging 80 per day for the 8 days of observation.

CONCLUSIONS

By the use of frozen aphids, egg production by *Hippodamia convergens* can be maintained throughout the year. Methods of freezing the aphids and feeding them to *convergens* adults have been worked out.

Of the various species of aphids tested, the poplar gall aphid (*Pemphigus populi-transversus*) has proved the most satisfactory.

If one were interested in large-scale egg production, it would be advisable to rear larvae through to adults, and work with newly-emerged adults exclusively. It would be necessary to feed them twice daily, preferably three times.

Individuals confined to a strict diet of frozen aphids through the larval and adult stages, produce fertile eggs.

Methods have not been studied for rearing *convergens* larvae in quantity on frozen aphids. During insecticidal work, frozen aphids have served well as food for the first instar (2).

The reactions of other coccinellids to frozen aphids have not been studied. From two incidental observations it was learned that *Coccinella trifasciata* and *Adalia bipunctata* feed readily on frozen poplar gall aphids. *A. bipunctata* was reared to the adult stage on them.

Technique for obtaining mass-egg production by *convergens* when living aphids are available as food will be reported in another paper.

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THE SEVENTH INTERNATIONAL CONGRESS OF ENTOMOLOGY, BERLIN, AUGUST 15-20, 1938.

Information concerning the Congress and concerning rates and routes can be obtained from either Professor A. R. Shadle, University of Buffalo, Buffalo, N. Y., or from Professor R. W. Leiby, Cornell University, Ithaca, N. Y.

PALAEMNEMA PICICAUDATA, P. ABBREVIATA AND P. BRUCELLI, NEW DRAGONFLIES FROM ECUADOR, WITH NOTES ON OTHER PALAEMNEMAS.

(ODONATA: PLATYSTICTIDAE)

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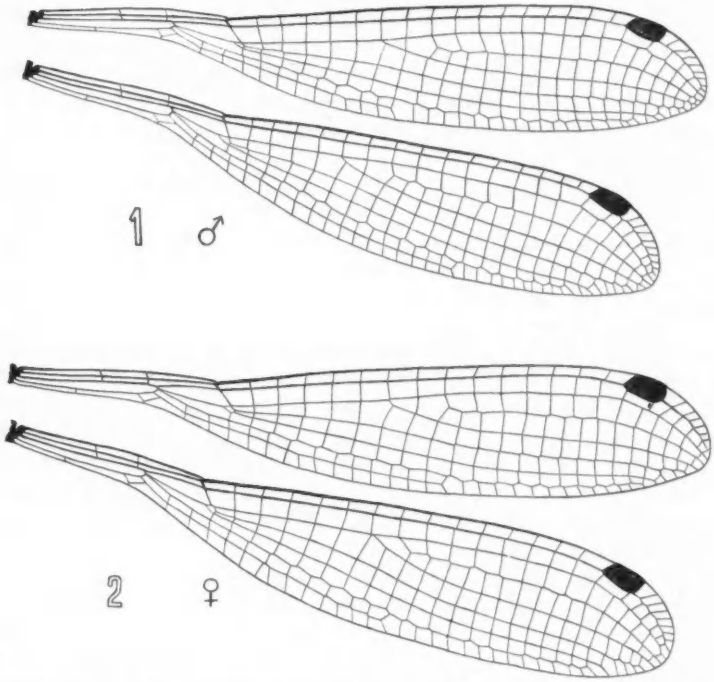
Ohio State University,
Columbus, Ohio

The species of Palaemnema discussed in this article are all that are known at present from Ecuador. The three new species come from the edge of the jungle on the lower eastern slope of the Andes in the headwaters of the Amazon. The fourth, *clementia*, is found in this area and also on the coast about Guayaquil. This is a widely spread species, having been recorded from Colombia, Venezuela and Peru. According to a recent letter, Dr. Calvert thinks that the majority of the species in this genus have a very limited or local distribution. This appears to be the case when we consider the published records. The species *clementia* apparently is an exception, all the more interesting, because in Ecuador its western area of distribution is shut off from its eastern area by a double range of the very high Andes mountains.

During the four years during which Mr. William Clarke-Macintyre has been collecting Odonata about each of many camps only the few specimens of Palaemnema listed have been caught. They are open woods insects which have the habit of sitting on sticks and other trash in rather open areas. Because of their position near the ground, and because of the banded, dull coloration, they are very difficult to see while the collector stands upright. E. B. Williamson took large series by crawling on hands and knees which put his eyes low enough to see the contour of the dragonfly rather than its color. When seen the specimen could usually be picked up by the fingers. By hand collecting Palaemnema on his knees on the ground, Williamson procured the only long series of species collected within a day or two in one area. Macintyre's series have been built up by one or two specimens at a time over a period of four years. However, from letters, there are very few areas in the Ecuadorean jungle as open as those described by Williamson (Calvert, 1931, p. 20).

Calvert's monographic study (1931) of Palaemnema has shown us what characters are of most value in separating the very close species. The inferior appendages of the apex of the male abdomen appear to have characters which are specific to each species. The character of the penis and color pattern have value but are usually duplicated in two or more species. The number of postnodals and size of the male have some value



Figs. 1 and 2. *Palaemnema picicaudata* n. sp. Wings of male (No. 107) and of female (No. 120).

but the size of the female is very variable. Because of the value of the characters of the inferiors we have figured these carefully and have added figures from our notes of various related species which came in question while studying the Ecuadorean material. Frankly we enjoy a well illustrated paper. It was Calvert's numerous illustrations (1931) which made it at all possible to determine the newness of our new

species. The drawings of other material (figs. 38–48, *mihi*) were made in the E. B. Williamson Collection at the Zoological Museum of the University of Michigan, during a four-day stay devoted to a study of the material there, practically all of which was listed in Calvert's monograph. We wish to thank Prof. F. M. Gaige, Director, for this privilege, and Mrs. L. K. Gloyd, in charge of the Collection, for help and advice on puzzling items.

All material was collected by William Clarke-Macintyre. The types will be deposited in the Williamson Collection in the Zoological Museum, University of Michigan, Ann Arbor, Mich.

The genus Palaemnema is particularly interesting because it is the only genus of the Platystictidae found in the New World. This family with the lost Cu_2 and reduced 1A, has the stature of the Coenagriid dragonflies but the nymph (Fraser, 1919) has a deeply cleft labium which suggests relationship to the Agriid series of subfamilies. The penes of Palaemnema and Platysticta are more like those of the Agriidae than like the penes of the Coenagriidae. Fig. 1 of the wings of the male and 2 of the female show the peculiarities of the platystictid venation.

Palaemnema clementia Selys

(Figs. 3–11)

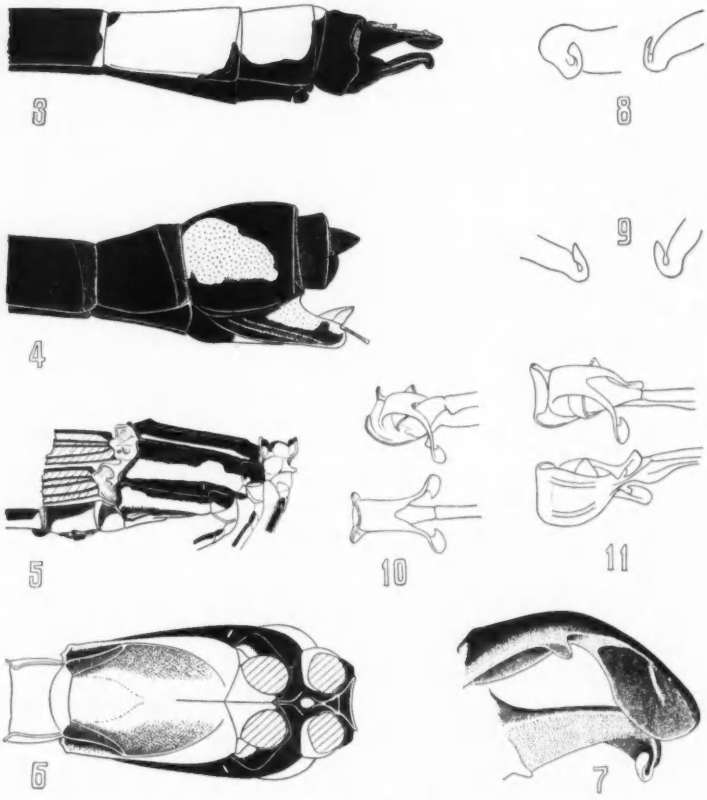
Selys, 1886. Revision du Synopsis des Agrionines.
Mem. couron, Acad. roy. Belg. Classe sci. XXXIII, p. 148.

The unique type, now lost (Calvert, 1931, p. 93), was from "S. Esteban (Venezuela)." In the same publication (1931), Calvert discusses 69 males and 17 females now in the Williamson and Calvert Collections which were collected from January to April, 1920, by J. H. and E. B. Williamson and W. H. Ditzler at Macuto, San Esteban, Carabolo, Boqueron, La Fria and Tachira in Venezuela. Calvert (1909), and quoting him Ris (1916), list one male from Bonda, Dept. Magdalena, Colombia, now in the Carnegie Museum, Pittsburgh.

Cowley (1934, p. 203) lists one male from Chuchuras, Prov. Pasco, Dep. Junin, Peru (10.07° south); elevation 325 m.; collected by Dr. Paul Martin. This is the southernmost point of known distribution. The specimen is presumably in the Cowley collection.

In the Williamson Collection at the Zoological Museum of the University of Michigan we had the privilege of studying

the Williamson material after its study by Calvert (1931) and one unrecorded male collected by Felix Woytkowski in the Rjoja (Soritor) jungle about 900 m. above sea-level, in the Departmento of San Martin, Peru, 6.04° south.



Figs. 3–11. *Palaemnema clementia* Selys.

Our own material of this species comes from two areas, one male collected by Clarke-Macintyre, September 26, 1934, on the Rio Chucapi, a small creek west of the Hacienda Ila, which empties into the Rio Anzu. The elevation is 600 to 700 m. Thus this single male is from east of the Andes. The remainder of our material consists of 23 males with 6 females collected on

March 3–5, 1938, in the Prov. de los Riós (near Guayaquil on the coast) which is a low area almost at sea-level ("15 meters" elevation on envelopes), and west of the Andes.

A comparison of the single male collected east of the Andes (Rio Chucapi) with the series taken in Prov. de los Riós, west of the Andes, can mean little as the single male might be extreme in its characters. Obviously it was extreme enough in behavior to get caught, as Clarke-Macintyre had collected over this area each month for several years. Our figs. 3, 5 and 11 are of the Rio Chucapi male. This male has more black on head and thorax than have the males from west of the Andes. In the former the postclypeus has mere traces of blue on its outer angles. In the western males the postclypeus is always with its anterior half blue and frequently the black reduced to a mere line at its base. On the thorax the western specimens usually have the black humeral stripe a mere line or if broad it is usually forked above. In nearly all the males seg. 9 is distinctly blue while seg. 8 is more violaceous though in some both are violaceous. There is no doubt in our mind that all specimens are *clementia* according to Calvert's (1931) concept of this species. (Figs. 4, 6–10 are from material collected in Prov. de los Riós, on the coast.)

Palaemnema picicaudata n. sp.

(Figs. 1, 2, 12–18)

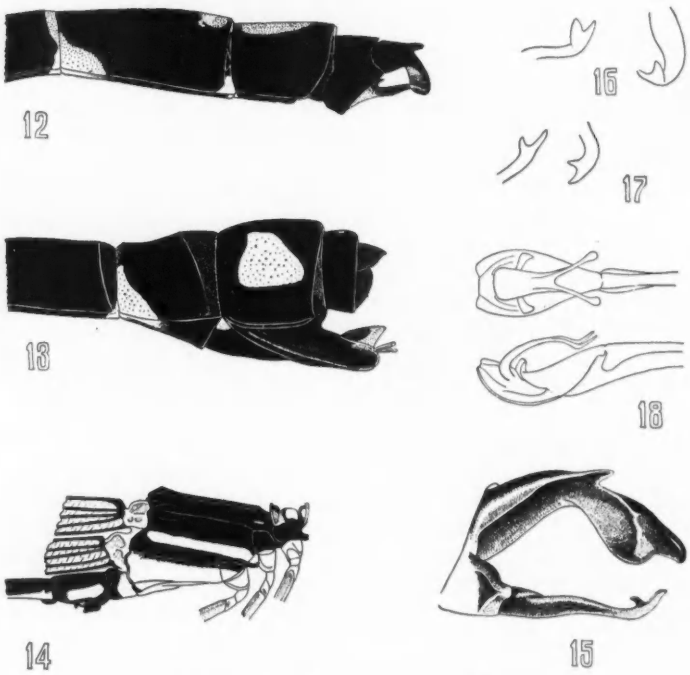
A black species with clear wings, a bluish white stripe across face, a minute pale shoulder spot, the lower side and under surface of thorax yellow, a narrow gray metepisternal stripe; seg. 9 with or without some dorsal blue. Male (10 specimens), abdomen, including appendages, 34–39 mm., usual length 37 or 38 mm.; hind wing 22–27 mm., in 5 of 10 males 24 mm. Female (15 specimens), abdomen 28–33 mm., usual length 30 or 31 mm.; hind wing 23–26 mm., usual length 23–25 mm. Postnodals, male, fore wing, 15–17, usually 15 or 16, in hind wing 14–17, usually 14 or 15; in the female, fore wing 15–17, usual number 15 or 16, hind wing 13–17, the usual number 14 or 15.

Picicaudata = fish-tailed, in reference to the two, thin, triangular lobes on the apex of the inferior appendage of the male.

Male, holotype.—Head black; labium pale, the glossae brown; anteclypeus and upper three-fifths of labrum creamy white, genae and

bases of mandibles bluish white, the whole bluish and white area forming a whitish band across the lower part of the face. Second segment of antenna medium brown.

Prothorax (fig. 14, holotype) in shades of dark brown with a small, pale (yellow?) spot on side of anterior lobe, this followed by a conspicuous oval blue spot covering three-fourths of side of middle lobe, back of the latter a bluish gray area on outer end of posterior lobe. Lower side of prothorax black and dark brown. Synthorax black



Figs. 12–18. *Palaemnema picicaudata* n. sp.

down to first lateral suture except for a minute dash of pale (blue?) on anterior end of mesepisternum just above mesinfraepisternum. The latter black above shading into brown below. Anterior half of metepisternum bluish grey, forming a stripe of uniform width which does not quite reach the alar carina and which below is continuous with the pale color of the metasternum. Anterior edge of metepimeron narrowly infuscated, upper two-fifths of metinfraepisternum black. Lower side and ventral surface yellow except some mottling of sternum between the legs. Coxae and trochanters pale, femora and tibiae lightly infuscated, with black apices. Wings clear with dark brown stigmas.

Abdomen dark brown to black (fig. 12, holotype). Seg. 1 pale on lower side, 2 with an elongate parallel-sided pale bar, along its lower side (fig. 14). Seg. 3 with lower anterior angle on side pale. Segs. 4–7 with an anterior pale ring; 8 with a large spot in lower anterior angle of side, a small pale brown area on apex of dorsum; 9 broadly brown on dorsal surface but the paler area not reaching apex of segment by one-fourth the length of dorsum. Seg. 10 and appendages black.

The appendages of a paratype (No. 107) are shown in fig. 15. They are identical with those of the type. The dorsal spine of the superior is at 0.50 of length of the appendage, apex of superior deeply notched with the lower lobe broadly rounded. Inferior appendage slender, its apex forked, the lower lobe the longer and curved entad, the shorter upper lobe curved cephalad (figs. 15–17).

The penis (fig. 18) is of Calvert's type B with no notch in the tip of the filament (from paratype No. 107).

Female, allotype.—Color pattern of female identical with that of male except for a few details. Prothorax with blue spot of male on middle lobe less brilliant and usually supplanted by brown; the same for the shoulder spot on anterior end of mesepisternum. Segment 2 broadly pale below. Segs. 3–7 ringed as in male. Seg. 8 with anterior pale spot on lower side, 9 with a large spot on side (fig. 13), 10 black, cerci, epiprocts and tip of ovipositor brown.

The identification of the female rests on the presence of the obscure shoulder spot, the number of postnodals, the identity with male of locality and date.

Holotype, male, collected near Napo, Oriente, Ecuador, February 24, 1934, elevation about 400 meters. *Allotype*, female, collected March, 1937, on the Rio Jatun Yacu, near the Hacienda Ila, elevation 700 meters, in Prov. Oriente, Ecuador; collector, William Clarke-Macintyre. Types in the Williamson Collection, University of Michigan.

Paratypes are 9 males and 14 females, all captured at an elevation of about 700 m. near small streams in the fork of the Rio Napo and Rio Anzu: 8 from Napo, 15 from the Rio Jatun Yacu, 1 from Partidero on the Anzu and 1 from Upper Ilapulin, a small creek in this area between the Jatun Yacu and the Anzu. The two tenerals were taken in January, the longest series in March, other months are February, October and December.

The most noticeable variability is in the color of segments 8 and 9 in the males. Four have these segments black on dorsum, 2 are colored as is the holotype with a large dorsal spot on seg. 9 and a smaller spot on seg. 8. One has a large spot on 9 and none on 8; one a pair of small blue spots on dorsum of 9, and one a minute median dorsal blue spot on 9.

Both males and females vary in the conspicuousness of the minute, pale shoulder spot. In both sexes it varies in color from a distinct blue to brown or to a mere indication of slight difference in shade from the surrounding dark brown or black of the mesepisternum. It is always present when looked for closely enough with a medium magnification and a good light.

Relationships.—This species keys out in Calvert's (1931) key (p. 27) to *mutans* Calvert of Venezuela. We have compared our material carefully with 3 males and 1 female of *mutans* (paratypes) in the Williamson Collection at the University of Michigan and find our material distinct from *mutans* in: (1) The tip of the inferior appendage of the male. In *picicaudata* it is a flat, thin, forked, "fish-tail" tip, usually the inner or apical lobe the longer of the two. In *mutans* (figs. 44, 45) the apical fourth of the inferior appendage is trough-shaped with the concavity uppermost. The apex turns up and is a hemispherical knob. It may have on the ental face of the terminal knob a minute tooth (fig. 44) directed entad. (2) Each of the three males of *mutans* at Ann Arbor has much more blue on apex of abdomen. The apical fourth or third of dorsum of seg. 8 and all of dorsum 9 and 10 is blue. In *picicaudata* the apex of the abdomen may be wholly black or may have blue on segs. 8 and 9 varying from small specks to the extent shown by the holotype (fig. 12). (3) *Picicaudata* differs from *mutans* in having the dorsal spine of the superiors nearly twice as long and more erect than in *mutans*. (4) Under low power with transmitted light the pterostigmas of *mutans* are a dull wine red, in *picicaudata* they are brownish to black.

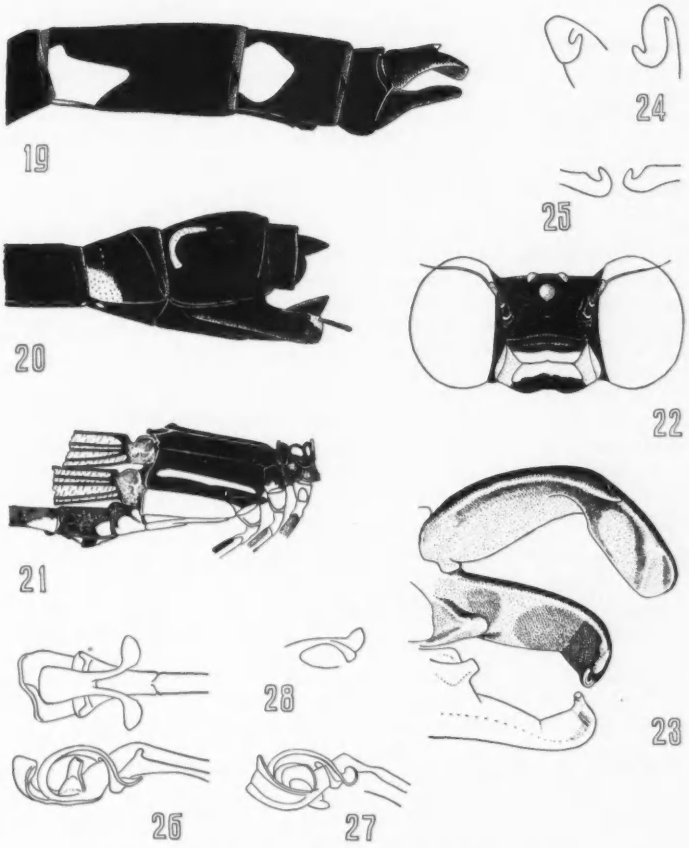
Palaemnema abbreviata n. sp.

(Figs. 19–28, and 38, 39)

A blackish species with clear wings, a bluish white stripe across face; narrow blue lateral thoracic stripe, lower sides and ventrum pale; abdominal segments 8 and 9 with pale spot on side. Male (5 specimens), abdomen including appendages 35–37 mm. long, (3 males with abd. 36 mm.), female (1 specimen), abdomen 35 mm. Hind wing, male 25–26 mm., (4 males with hwg. 26 mm.), of female 26 mm. Postnodals in male, fore wing, from 18 to 21, usually 19, in hind wing 16 to 19, usually 17; in the single female, fore wings, 17 and 20, in hind wings 16 and 16.

Abbreviata = abridged, in reference to the fact that the metepi-

sternal blue stripe does not contact the pale color of the ventral surface of the metathorax. This character is unusual in the several species with such stripes.



Figs. 19–28. *Palaemnema abbreviata* n. sp.

Male, holotype.—Under side of head black; labium pale with glossae brown. Face and top of head black with anteclypeus, bases of mandibles, genae and upper half of labrum bluish white. (These areas form a glistening bluish white band across lower part of face. Fig. 22.)

Prothorax in shades of dark brown to black with oval blue spot on side of anterior lobe and a larger oval blue spot on side of middle lobe (fig. 21, drawn from paratype male No. 202). Mesothorax

black except lower third of mesinfraepisternum pale; sternum pale mottled with black. Metathorax pale with lower two-thirds of metepisternum black as is also upper two-thirds of metinfraepisternum. This leaves a narrow, pale blue stripe along anterior edge of metepisternum which does not touch the alar carina above *nor does it reach the sternum between middle and hind legs* (fig. 21). Legs with coxae and trochanters pale (yellowish?). Femora yellow, middle third and apex brown, spines brown, tibiae yellow with outer side brown, spines orange, tarsi brown. Wings entirely clear, veins and stigmas black.

Abdomen dark brown to black; lower third of seg. 1 (fig. 21) pale (yellow?), a spot of pale on lower anterior angle of seg. 2, also one similar on seg. 3. Segs. 4–7 with a pale ring on anterior end twice as long below as above and along middorsal line four times as long as the structural ring on apex of preceding segment. Seg. 8 black with romboid pale spot in lower anterior angle of side (fig. 19, drawn from paratype male No. 202), this spot two-fifths length of segment. Seg. 9 black with blue angular spot on middle of side at anterior end, length equals one-half that of segment. Seg. 10 black, superior appendages black, inferiors dark brown, dorsal spine on superiors dark brown.

The appendages of a paratype (No. 202) are shown in fig. 23 and in figs. 38 and 39. Notice superior with strong dorsal tooth at 0.60 of length, apex broadly rounded, inner edge of apical arm parallel to outer edge. Inferior wide almost to apex then terminating in a minute turned-up hook (figs. 23–25 and 38, 39); inner basal tooth as wide as high, strongly developed, its height equal to one-third the width of the apex of the superior. Figs. 24 (No. 201) and 25 (No. 202) show end views of the inferiors.

The penis is of Calvert's type B which shows a broad v-notch in tip (fig. 28 of specimen 204, inside ventral view of right lobe). Fig. 26 is of No. 204, while fig. 27 is of No. 201. All are paratypes.

Female, allotype.—Color pattern of female identical with that of male holotype except for segments 8, 9 and ovipositor. (See fig. 20.) Seg. 8 with lower anterior angle of side pale, and on sternum below this mark a small oval pale spot. Seg. 9 with a blue crescent on upper anterior area of side, its convex side forward. Tip and lower edge of ovipositor mottled with brown.

The female happened to be papered by the collector in the same envelope with male No. 204. As a large part of all envelopes sent by Clarke-Macintyre contain two specimens, frequently generically different, this can be interpreted merely that the two specimens were collected the same day and in the same locality as indicated on the envelope. The identification of the female rests on identical size, same general number of postnodals and especially on *the short metepisternal blue stripe which, as in the male, is not continuous below with the pale areas of the metathoracic sternum.* Less positive but with value is the color pattern of segments 8 and 9 which have conspicuous lateral spots as in the male.

Holotype, male (No. 203) and *allotype*, female (No. 205), collected at 700 mtrs. elevation, March, 1937, on the Rio Jatun Yacu, a tributary of the Rio Napo near Hda. Ila, Prov. Oriente, Ecuador, by William Clarke-Macintyre. This area is on the lower, eastern, jungle covered slopes of the Andes. The types will be deposited in the Williamson Collection in the Zoological Museum, University of Michigan.

Paratypes consist of four males, one from Baños, 2,000 m. elevation, February, 1936, two from Rio Jatun Yacu, 700 meters elevation, March, 1937, and one a teneral, from Partidero, up the Rio Anzu from the Hacienda Ila, October 12, 1935. All are uniform in characters with the holotype, except the teneral which has the anal bridge as in Calvert's (1931) fig. 12, pl. 1.

This species runs out in Calvert's key (1931, p. 28) to item "00," which includes *apicalis*, *carmelita*, and *reventazoni*. Of the three species it more nearly fits *apicalis* Navás (1924). However, it differs from the latter in that the superior tooth of the male superior appendages is at 0.60 of appendage length (at 0.43 in *apicalis*); in that the basal tooth of the inferiors is about one-third to two-fifths as long as width of apex of superiors (one-fourth in *apicalis* in Calvert's key, but more nearly one-sixth in his fig. 61 A, pl. XII). Calvert's fig. 61 E, pl. XIII, shows a narrow notch on the ental face of each apical lobe of the penis. I have examined the penis of *abbreviata* in various positions and in excellent light at 87 magnifications both dry and thoroughly relaxed and can find no such notch. This character was carefully checked by L. K. Gloyd. Calvert's other figures of *apicalis*, 61 D and 61D', are remarkably like figures 26–28 of this species.

Abbreviata differs from *carmelita* Ris (1918) very strikingly in color: in the latter segs. 8–10 are black while the thorax is pale (extensively blue in well preserved specimens in Williamson Collection). In *carmelita* (figs. 40–41) the inferiors lack an internal basal spine. *Reventazoni* Calvert (1931) is set off by a deep rectangular notch in the apex of the superior appendages and by the blue of the metepisternal stripe being continuous with the light color of the ventor. *Abbreviata* has been compared with material of *carmelita* and *reventazoni* in the Williamson Collection at Ann Arbor but *apicalis* Navás is a single specimen returned by Calvert to Zaragoza, Spain.

The male abdominal appendages of *abbreviata* are very nearly similar to those of the male *clementia*. Compare figs. 7 and 23. However, there are constant differences even in the appendages. The main distinguishing characters of *clementia* are the greater extent of blue on thorax and abdomen (compare fig. 5 with 21 and 3 with 19) and the black areas on the under side of the thorax posterior to the third pair of legs (fig. 6). In *abbreviata* the ventral thoracic area posterior to the third legs is pale.

Palaemnema brucelli n. sp.

(Figs. 29–37)

A black species with clear wings, a bluish white stripe across the face, two blue spots on an otherwise dark prothorax, a narrow blue metepisternal stripe, lower side and ventor of thorax pale, seg. 9 with or without a blue saddle on dorsum. Male (18 specimens), abdomen, including appendages, 35–39 mm., usual length 36–38 mm.; hind wing 25–28 mm., usual length 26–27 mm. Female (13 specimens), abdomen, 31–38 mm., more frequent lengths 37 or 38 mm., hind wing 24–29 mm., the more frequent lengths 27 or 28 mm. Postnodals, male, fore wing 16–21, usually 18 or 19, in hind wing 15–19, usually 17 or 18; in the female, fore wing 18–20, usually 18 or 19, hind wing 16–20, usually 17 or 18.

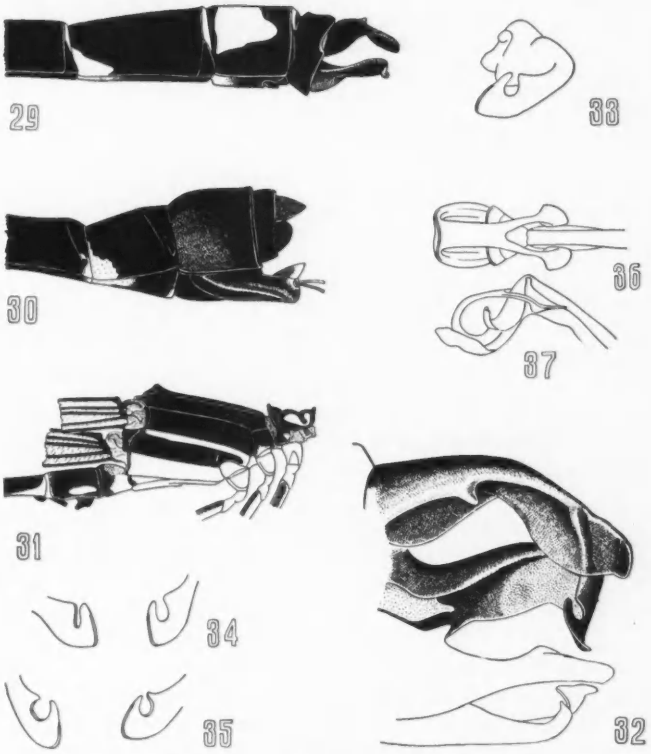
Brucelli = of Bruce, The Smaller. Named for my son, Bruce Hamilton Kennedy, God-son of Edward Bruce Williamson, and in reference to the fact that *brucelli* is a close relative of *brucei* Calvert.

Holotype, male.—Ground color of head black; labium pale; anteclypeus, upper two-thirds of labrum and bases of mandibles a glossy creamy white; genae pale, perhaps bluish in life, this whole area forming a glistening white band across the lower part of the black face. Antennae, first segment black, second dark brown.

Prothorax (compare with fig. 31 of paratype male No. 3) in black and shades of dark brown, except narrow line of pale (yellow?) along lower edge of side and two blue oval spots, one each on the side of the fore- and of the middle lobe. In some males these are joined below. Synthorax black above and down the sides to the metepimeron, except for a narrow bluish gray stripe, one-fourth as wide as the metepisternum, on the anterior edge of that sclerite; the lower end of this pale stripe continuous with the pale ventral region. Mesinfraepisternum black except its lower edge pale. Metinfraepisternum pale as are the coxae, trochanters, and ventral surface of metathorax posterior to third legs; ventral surface between the pairs of legs mottled with dark.

Femora with apex narrowly black, preceded by a short pale ring, otherwise dusky brown as are the tibiae and tarsi. Wings clear with black stigmas.

Abdomen black. Seg. 1 pale on lower half of side (compare with fig. 31); 2 with side dark above and pale below, the contact of the two areas being a nearly straight line from lower posterior angle of side to upper anterior part of side; 3 with a narrow triangular spot on the lower



Figs. 29–37. *Palaemnema brucelli* n. sp.

angle of anterior end of side; segs. 4–7 each with a basal pale ring twice as long along ventral side as along middorsal line; there it is three to four times as wide as the apical structural ring on the preceding segment; 8 with a triangular pale spot on anterior end of lower side similar to that on paratype No. 3 shown in fig. 29; 9 with a large blue saddle mark whose anterior edge is separated from anterior end of segment by a narrow black area, whose blue sides reach below the middle line of the side and whose lower edge reaches the posterior end of 9 and is

one-half longer than the middle of the blue saddle. Anterior end of sternum of 8 and of 9 pale. Seg. 10 black and appendages largely black. Fig. 29 is of a paratype male, No. 3, but very similar in color to that of the holotype.

The appendages of the holotype are shown in fig. 32. The dorsal spine of the superior is at 0.39 of the length of the appendage. Apex of superior with tip slightly angled entad so that in a certain position (our fig. 32) the tip appears shallowly notched. Inferior appendage broad to the thin apex which, on its dorsal edge, has a notch, rounded or oval, that extends *below middle line* of apex. The thin end of the inferior turned entad, *its apical point turned caudad.* Internal basal spine of inferior strong. Fig. 33 is an end view of inferior shown in fig. 32 (holotype male): Fig. 34 of male No. 6 and fig. 35 of male No. 3.

Penis of Calvert's type B (figs. 36 and 37), the terminal filaments with simple triangular apical lobes. Fig. 36 is of specimen No. 3. Fig. 37 is of male No. 20, the holotype.

Female, allotype.—Color pattern of female (allotype is No. 70) similar to that of the male. Under surface of head mottled with pale; lower edge of labrum brown; outer angles of postclypeus pale.

Prothorax brown without blue spots. Black of side of synthorax extending slightly onto anterior edge of metepimeron.

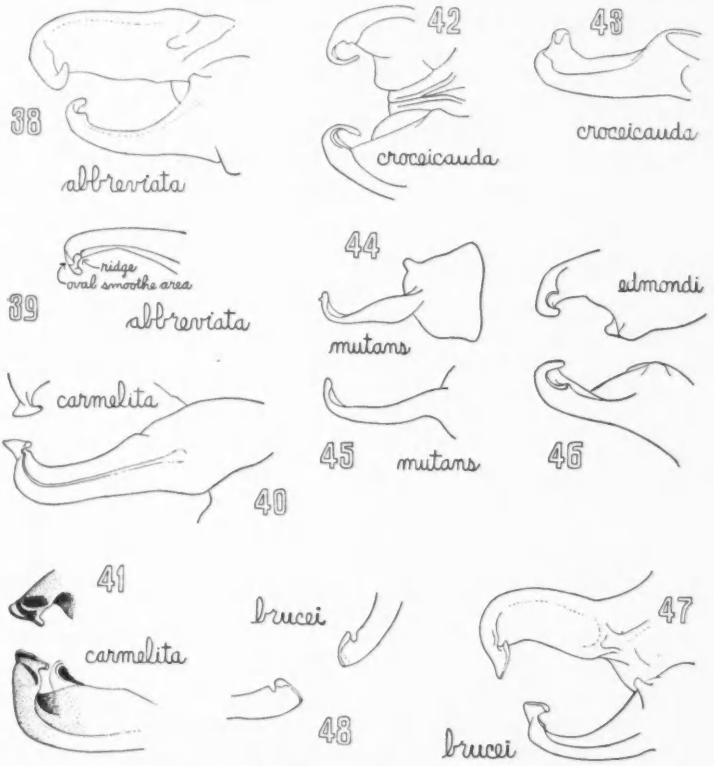
Abdomen colored as in the male, but seg. 2 with a slender triangular pale spot on anterior end of side. Seg. 9 with a large indistinct pale brown area in the lower anterior angle of side (fig. 30). Cerci, paraprocts and apex of ovipositor brown.

The identity of the female was determined partly by elimination, but also by the size of the series as checked against the number of males, by color pattern, by physical size and general number of postnodals.

Holotype, male, collected near Hacienda Ila on the Rio Anzu, Prov. Oriente, at about 500 m. elevation, on December 18, 1936. *Allotype*, female, collected on the Rio Verde, Baños, Prov. de Tungurahua, at about 2,000 m., October 25, 1935. The types in the Williamson Collection, Zoological Museum, University of Michigan.

Paratypes.—These consist: (1) Of 17 males from the Prov. Tungurahua and the Prov. Oriente, collected in the edge of the jungle on the headwaters of the Rio Napo and the Rio Pastaza at elevations from 400 m., near Napo, to 2,000 m., near Baños. They were collected in the following months: March, May, October, November and December. (2) Of 12 females, 10 of which were taken at Abitagua on the Rio Pastaza in October and November, 1936, and 2 at Partidero on the Rio Anzu, October, 1935. In all this series no more than two specimens were taken on any one day while the series of collections was scattered over a period of three to four years.

This species runs out in Calvert's key (1931, p. 27) to rubric "BB. abdominal segment eight chiefly black; no dark metepimeral or metasternal stripes." Our specimens with blue on seg. 9 will run to rubric "O" (*mutans*, *brucei* and *azupizui*), while those with a black seg. 9 run to "OO" (*apicalis*,



Figs. 38–48. Palaemnema. Inferior appendages of various species more or less related to the four Ecuadorean species discussed.

carmelita and *reventazoni*). By the inferior appendages of the male, *mutans* Calvert does not belong in this group while *brucelli* does. (See fig. 44 of specimen No. 406 and fig. 45 of No. 416, both from Tachira, Venezuela, in Williamson Collection.) By the slender inferior appendage *mutans* belongs nearer our species *piscicaudata*.

By the inferior appendage, *brucelli* is close to *brucei* Calvert. See figs. 47 and 48 of No. 284, paratype, in Williamson Collection, from Cristalina, Colombia. The inferiors of *brucei* appear to differ from those of *brucelli* only in having a shallow apical notch. The depth of this is *less than one-half* the width of the tip of the appendage and it is an open V. In *brucelli* it is equal to or greater than half the width and is oval or circular in shape. *Brucei* has a blue shoulder stripe (Calvert, 1931, Pl. XX, fig. 89), *brucelli* is without. In *brucei* segs. 8, 9 and 10 are blue dorsally, in *brucelli* the blue on 9 is a saddle spot extending below middle of side while 10 has no blue color.

Azupizui Calvert, which we have not seen, is a unique male from Peru and now in the Cornell Collection. It appears to be close to *brucelli* by general shape of the inferiors (Calvert, 1931, Pl. XII, figs. 60A, B, F, F' and G) but the latter have little or no terminal notch. Seg. 10 is blue above, and the penis has a notch in the tip of each terminal filament.

Apicalis Navás (1924, pp. 14–15) from Medina, Colombia, is so close to those *brucelli* that have no blue on seg. 9 that the most distinctive difference we find is in the shape of the apex of the terminal filaments of the penis. In Calvert's fig. 61 E, (Pl. XIII, 1931) the terminal lobe has a deep narrow notch. The penis of our species *brucelli* was examined, both dry and thoroughly relaxed, by the writer and the observations checked by L. K. Gloyd under the binocular at 87 diameters and no such notch could be observed. (See figs. 36 and 37, ventral and lateral views.) If the inferior appendages of *apicalis* are drawn by Calvert (1931, Pl. XII, 61 F, 61 G') so as to show the greatest width of the terminal notch, then this is narrower than in any specimen of *brucelli*. Further, in the latter the inferior appendage has an angle on the lower side of the truncated tip. In Calvert's figs. 61 F and 61 G' this angle is less evident. (See our figs. 33, 34 and 35 of this character in *brucelli*.) Finally, the inner basal tooth on the inferiors of *brucelli* is twice as large as that in *apicalis* (Calvert, 1931, Pl. XII, fig. 61 A).

Carmelita Ris (1918) from Villa Elvira, Colombia, has inferiors (figs. 40 and 41) very close to those of *brucei*, having a similar shallow apical notch. *Carmelita* differs from *brucelli* in its extensively blue thorax and in the lack of a basal internal tooth on the inferiors.

Reventazoni Calvert (1931, p. 85) from Costa Rica, with broad truncate inferiors, differs at once from *brucelli* in the tips of these (Calvert, 1931, Pl. XIII, figs. 63 A–63 G) and in the deeply notched apex of the superiors.

Croceicauda Calvert (1931, p. 96) and *edmondi* Calvert (1931, p. 99) were checked at Ann Arbor as both had inferior appendages with a large circular apical notch as in *brucelli*. These appear to be in the general group discussed but more distantly related. See figs. 42 and 43 of inferior appendages of *croceicauda*, holotype male from Cristalina, Colombia, and fig. 46, *edmondi*, a posterior dorsal view of the inferiors of a paratype male, No. 303, from Cristalina, Colombia. Neither of these species has inferiors with a distinct internal basal spine.

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* = Not seen by author

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1920, **Kennedy, C. H.** The phylogeny of the Zygopterous dragonflies as based on the evidence of the penes. Ohio Jour. Sci. 21 (1): 19-29, Pls. 1-3. (Page 24, the Platystictinae erected for Palaemnema, Platysticta and Protosticta. Suggested relationship to Agriid subfamilies on Fraser's (1919) description of larva of Protosticta.)

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*1923, **Navas,** (*Palaemnema apicalis* indicated without description, on page 361, Bol. Soc. Colombiana Cien. Nat. vol. 12. Medina, junio de 1918.)

1924, **Navas,** Odonatos Nuevos o Interesantes. Mem. Real. Acad. de Cien. y Artes de Barcelona. (XVIII (13), tercera epoca: pp. 14-15 and fig. 8. (Description of *Palaemnema apicalis*.)

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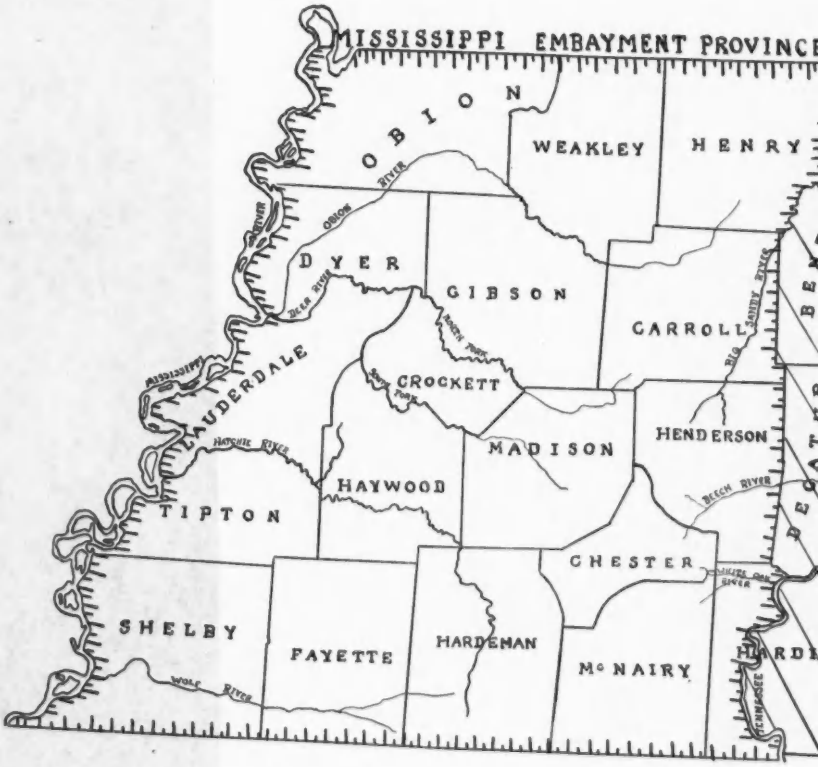
A BOOK OF BIRDS, by MARY PRIESTLEY, pp. 1–384, 82 wood engravings. 1938. Published by THE MACMILLAN COMPANY, 60 Fifth Ave., New York. Price, $2.50.

From Snedecor's "Statistical Methods" to Mrs. Priestley's "A Book of Birds" is a long jump for any reviewer. It takes this reviewer from his pedantic middle age to his romantic youth when sensory impressions of nature were more important to him than design of experiments and validity of conclusions. In those glorious days he was introduced to birds on the Riverton, N. J., golf course by his father in entomology, William Moore (golf was not involved). And later he went "birding" with an enthusiastic ornithologist, L. A. Hausman, of New Brunswick, N. J. So the world of birds was opened for him with all the joys and thrills that every bird-lover knows and that Mrs. Priestley has tried to capture in her book. But now, alas, from spring to fall the birds come and go scarcely noticed by this reviewer, "who vexes all the leaves of his life's book . . ."

Mrs. Priestley's book is an anthology of brief quotations from the better English literature dealing incidentally or primarily with birds. Her selections are not arranged in systematic, chronological, or any other kind of order that the reader could detect, but rather are published in the chance sequence of her scrap-book, prose interspersed with poetry. Although interesting scientific facts can be gleaned from some of the prose selections, it was not the purpose of the writer to appeal to the minds but to the emotions; or in her own words, "I have tried to make this a companionable book, a book meant for anybody who has ever taken a moment's joy in watching a bird." To this reviewer, whose emotions are not entirely atrophied, she has succeeded, particularly in her selection of verse. The poets' bird, the nightingale, takes the honors, but Keats' "Ode to a Nightingale" is absent, and Shelley's skylark is missing, perhaps because they are too well known. But we find Coleridge's albatross and Robinson Crusoe's parrot present. This reviewer is most grateful for the inclusion of a touching lyric by Robert Louis Stevenson on a sea-gull that had strayed inland. Perhaps only one who has worked on a farm in the East or Middle West can appreciate Hoosier poetry, but the reviewer wishes that Mrs. Priestley would consider bits from James Whitcomb Riley for her scrap-book. Could a better description of a bluejay be found than this? "Mr. Bluejay, full o' sass, in them base-ball clothes o' his, sportin' round the orchard jes' like he owned the premises!"

The illustrations in "A Book of Birds" are wood engravings by C. F. Tunnicliffe. They add an artistic quaintness to the book, but, of course, would be of little help in identification of species. Through the two indexes one can find selections by his favorite authors or passages on particular birds, listed only by common name.

What has all this to do with entomology? Nothing whatever. Any reader of the ANNALS who objects to this consumption of space and excursion into literature can complain to the managing editor who handed this book to the reviewer and thereby prevented him from seeing any birds in the morning. Moreover, the managing editor can also be blamed for the personal irrelevancies in this review, for he himself has set the example.—F. L. C.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LAUDERDALE
CROCKETT
HENDERSON
HATCHIE RIVER
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FAYETTE
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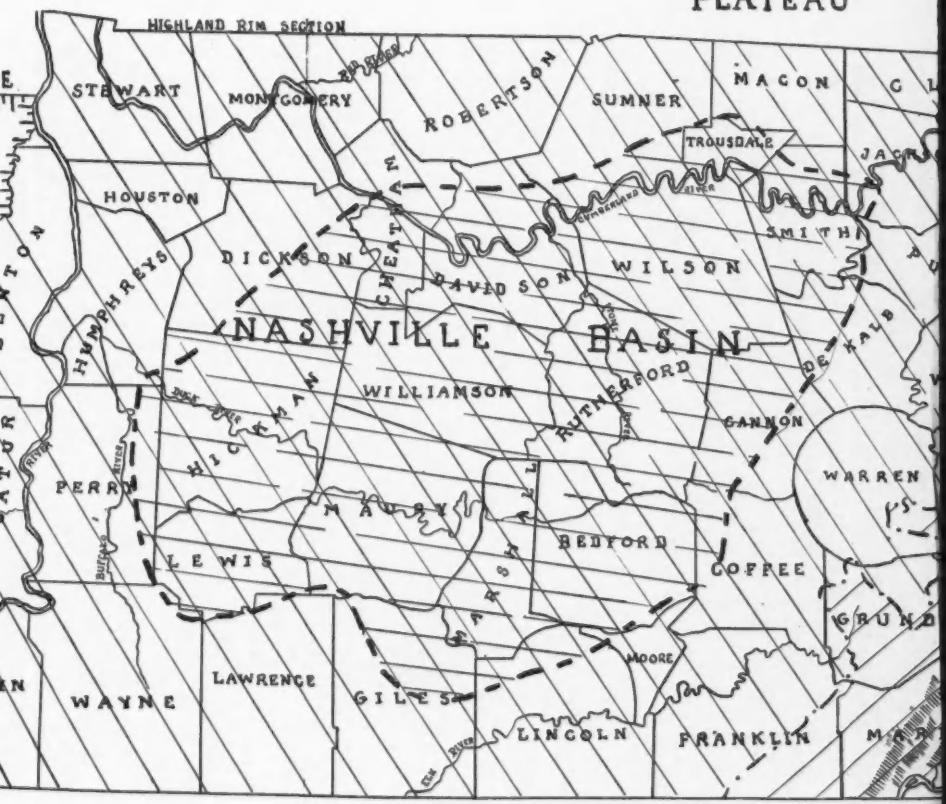
McNAIRY
WOLF RIVER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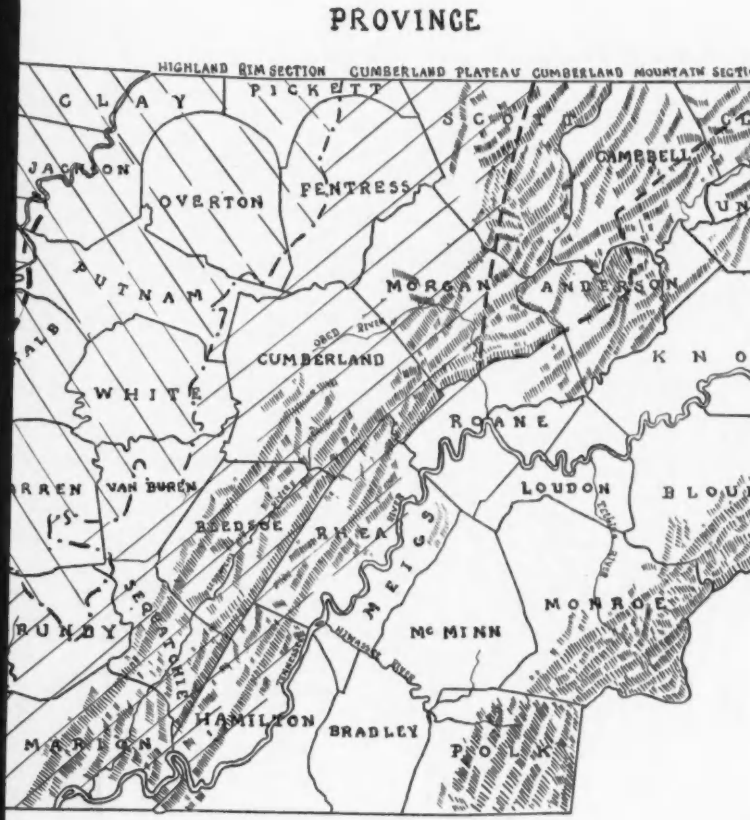
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ROANE
VAN BUREN
LOUDON
BLOUNT
BLEDSOE
RHEA
MEIGS
McMINN
MONROE
BRADLEY
POLK
HAMILTON
MARION

TENNESSEE

Showing Ecological Regions

THE DISTRIBUTION OF ANT SPECIES IN TENNESSEE WITH REFERENCE TO ECOLOGICAL FACTORS

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Tusculum College,
Greeneville, Tenn.

This study was undertaken with two ideas in mind: (1) To get a list including as many species as possible of the ants occurring in Tennessee. (2) To determine what ecological factors influence their distribution.

The plan for collecting was to cover as many ecological situations as seemed advisable; at different altitudes, on dry ridges and in wet ravines, open situations and those of dense shade, hill and mountain slopes of all directions, different forest types, and substrata.

GENERAL DESCRIPTION OF REGION

Topographically the State of Tennessee can be divided into three main regions: (See map.)

The eastern or Highland region consisting of the Great Smoky Mountain Range on the south and eastern border, with the Tennessee Valley lying between the Smokies and the Cumberland Mountains on the north.

The central or Plateau region divided into the Cumberland Plateau on the east and the Highland Rim which circles the Nashville Basin to the west of the Cumberland Plateau.

The western portion from about the Tennessee River west, which is the Mississippi Alluvial Plain or sometimes called the Mississippi Embayment.

The eastern or Highland Province has an altitude of around 1500 feet in the valleys to more than 6,000 feet on the highest peaks of the Great Smoky Range. The rainfall averages about 45 inches in the valleys and from 55 to 60 inches in the mountains. The average summer temperature runs between 70° F. and 80° F. with the exception of a few areas in the mountains where it runs between 65° and 75°. The average winter temperature is around 40°. Since extremes are more important from the ecological standpoint than the average, the extremes of temperature for both winter and summer are noted. The highest temperature recorded for Tennessee is 105° and the lowest, —20°.

Tennessee is unglaciated. The parent soil of the eastern half of the Highland Region is sandstone and shale, while the western half is limestone.

The forest in this region is mostly mixed mesophytic and it is very difficult to pick out any forest type in many cases. In a rough way

the following classification is true of the mountain portion; starting at the bottom and in an ascending order, Oak-Hickory (scarce), Hemlock-White Pine (lower valleys), Oak-Pine (*Pinus rigida* and *Pinus echinata*) with Table Mountain Pine on the dry ridges, Oak-Chestnut, Tulip-Hemlock, Maple-Pea Wood, and above 5,000 feet, Spruce followed by Fir at an altitude of 6,000 feet or more.

In the valleys the first in importance is Oak-Chestnut followed by Oak-Pine and Beech-Maple (scarce).

The central or Plateau Province of the state has an altitude around 1,000 feet in the Nashville Basin to 2,000 feet in the eastern Highland Rim section. The annual rainfall averages 40 inches in the Basin and around 55 inches in the Highland Rim. The average summer temperature is between 70° and 80° and the winter average is 40°.

The parent material of the soil in the Nashville Basin is limestone while in the Highland Rim and Cumberland Plateau it is sandstone and shale.

The forest type predominant in the Nashville Basin is Red Cedar with a scattering of scrubby Yellow Oak and Winged Elm. In the eastern Highland Rim the predominant type is Oak-Hickory on the upland and exposed slopes while in the narrow valleys there is a mixed mesophytic forest. On the western portion of the Highland Rim the forest is Oak-Hickory with scattered *Pinus virginiana* and mixed mesophytic in the ravines. On the Cumberland Plateau Oak-Hickory is the predominating type. Here, however, there is a greater predominance of Oak than on the Rim. The Oaks are chiefly Post and Black. The soil here is sand which is several feet deep, thus the area is very well drained.

The western section, the Mississippi Alluvial Plain has an altitude of around 500 feet. The average annual rainfall is from 40 to 50 inches. The average summer temperature is between 70° and 80° and the average winter temperature is 40°.

The parent soil of the region just west of the Tennessee River is sand, clay and limestone, while the territory west of this region, almost to the Mississippi River, is loess and the region bordering the river is river alluvium.

In the counties bordering the Mississippi River the forest is a typical Swamp Forest type. On the bluffs it is mixed mesophytic, while back from the bluffs and along the streams, Pin Oak, Red Gum, Cypress and Cottonwood are common; while farther away from the Mississippi River on the better drained upland alluvial plain the forest is Oak-Hickory. The Oaks are Black, Post, Black Jack, Willow and Scarlet with a few White scattered throughout. Next to the Tennessee River on the cherty, well drained soil with greater relief, there is a drier type of forest consisting chiefly of Black Jack, Post, Black and Scarlet Oak. In the moist ravines are Tulip, Poplar, Beech, Hard Maple (northern) and Red Oak (southern).

METHODS AND POINT OF VIEW

Ants were collected over a period of five years. Since the writer lives at Tusculum College near Greeneville, Tennessee, rather intensive

collecting was done in that area, and he feels that most of the species in that area were taken. Collecting was done in several localities in other parts of the state. In June of 1935 the Mississippi Embayment region was worked but due to very wet weather just before and during the collecting time it was impossible to get into some areas of this region. In June of 1936, collecting was done in the Nashville area and due to the extreme dry weather at that time collecting was very poor, so without a doubt it will be found that there are several species in both these areas that the writer did not take. Data from collections made by C. H. Kennedy in the Great Smokies in Blount County are included.

W. M. Wheeler's keys were used in classifying many of the ants.[1]

Wheeler ('32) states that "Ants are so extremely sensitive to the degrees of temperature and humidity of their environment and to the character of its vegetation that many species or subspecies are confined to very narrow ecological habitats." With this in mind, in the following pages each species, subspecies and variety (where enough collections were made) is discussed in relation to the above ecological factors.

GENERAL DISCUSSION OF ECOLOGY AND DISTRIBUTION

It is apparent from the data on the different species, subspecies and varieties that Tennessee is an overlapping area of the northern and southern species of ants of the Eastern United States, as is true in any area as large as a state. It marks the southern limit of several northern species and the northern limit of several southern species.

Due to the mountains whose altitude provides temperature near that of the states farther north, many northern forms are common that are not found at the same latitude at lower altitude. Examples are: *Aphenogaster fulva aquia picea* Emery, *Aphenogaster tennesseensis* Mayr, *Formica sanguinea rubicunda* Emery, *Formica fusca subaenescens* Emery, *Leptothorax longispinosus* Roger, *Myrmica punctiventris pinetorum* Wheeler, and *Myrmica scabrinodis sabuleti* Meinert.

The Mississippi Embayment region and the Nashville Basin include some southern forms not reported from farther north. Examples are: *Aphenogaster texana carolinensis* Wheeler, *Crematogaster opaca depilis punctulata* Emery, *Camponotus caryae rasilis pavidus* Wheeler, *Camponotus* (*C*) *mississippiensis* Smith, *Strumigenys louisianae laticephala* Smith, *Strumigenys creightoni* Smith, *Strumigenys dietrichi* Smith and *Trachymyrmex septentrionalis obscurior seminole* Wheeler.

Temperature and humidity certainly seem to be the two most important ecological factors in the distribution of ant species in Tennessee.

Temperature may be more important at times indirectly as a factor in controlling evaporation than as a direct factor. Shelford states in

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[1]Identifications of many of the ants were kindly checked by Dr. M. R. Smith. I wish also to express my appreciation for help from Dr. C. H. Kennedy and Dr. Mary Talbot.

I am also greatly indebted to Dr. E. N. Transeau and Dr. P. B. Stockdale of Ohio State University, and Mr. Aaron Sharp of the University of Tennessee, for their help on the map of plant ecology of Tennessee.

"Animal Communities in Temperate America" that "The distribution and succession of animals is clearly correlated with the evaporation power of air." Temperature however must in itself be a factor in many cases where there is plenty of moisture regardless of temperature.

The amount of moisture certainly plays equally as important a part as temperature. Talbot ('34) says in regard to six species of Formica: "It was found that those living in drier places (black oak, dunes, pariries, etc.) were more resistant to dryness than those living where the moisture supply is more constant." In general ants are insects of rather dry situations but in such areas they are sensitive to minor differences in moisture. However, there are a few species in our area, usually found in very shady woods, that can endure a wet habitat during winter and early spring before the season of heavy brood rearing.

Food must play an important part, but many ants are able to use a great variety of food so this factor is hard to analyze.

Sunshine is perhaps a factor in some cases. It seems to attract some species to open and exposed places. It repels others which prefer to nest in shady woods.

Substratum is evidently a factor in a few instances. Sand seems to be necessary for the nesting site of at least one species. (Pheidole morrisi). Wood is necessary for several species of *Camponotus*. Very rotten wood is used by *Proceratium*.

Nesting sites in several cases seems to be an important factor. Several species are confined to logs: *Proceratium silaceum* Roger, *Aphenogaster tennesseensis* Mayr, *Aphenogaster lamellidens nigripes* Smith, *Strumigenys dietrichi* Smith, while some others only nest in the ground: *Trachymyrmex septentrionalis obscurior seminole* Wheeler, *Stigmatomma pallipes* Haldeman, *Sysphincta pergandei* Emery, *Crematogaster victma missouriensis* Pergande, *Dorymyrmex pyramicus* Roger and *Dorymyrmex flavus* McCook.

In the case of the slave making ants it is necessary for them to be in close proximity to the species which they enslave and thus their distribution is wholly determined by the distribution of the enslaved species.

Although the notes were searched closely the writer was unable to see that the type of ecological forest had any appreciable effect upon the distribution of any ant species.

One very interesting fact brought out in the collecting is the scarcity of ant mounds in Tennessee. In five years of collecting only one small mound was found. This was made by a colony of *Pheidole morrisi*. The nest was located at the foot of Graystone Mountain near Greeneville. It was in a burned over area and the second growth was Laurel and small oak (4–5 feet high). The substratum was sandy loam.

The reason for this scarcity of mounds may be due to two facts: (1) The soil is warmed to such a depth that mounds are unnecessary for incubation of the brood. (2) The state as a whole is well drained. The highland region due to the slopes, the Nashville Basin due to its underground drainage and the Mississippi Embayment due to its sandy soil.

For this reason the ants are not often forced out by the water table coming to the surface as it does in some of the low poorly drained prairie regions. Ants in regions that are flooded several times each summer get away from the water by building mounds into which they can move when their galleries are flooded.

The fact that ants are scarce on the slopes of the mountains is a very interesting one. The base and the tops of the mountains have a rather abundant ant fauna, but there is very poor collecting on the slopes. It may be due to the rather rapid wearing or movement of the soil on these slpoes. It may be due to some lack of foods.

The distribution of *Pheidole* and *Aphenogaster fulva aguia picea* are significant enough to bear mentioning. In the valleys several species (*Pheidole commutata, vinelandica* and *crassicornis*) are very common, but above the base of the mountains they are absent. Diligent search produced no results even 100 feet above the valley floor. Their absence may be due to the rapid wearing of the slopes and to temperature.

Aphenogaster fulva aquia picea was limited to the tops of the mountains above 5,000 feet, and was most plentiful at 6,000 feet or more. This is a common ant in northern Ohio and other northern states and is probably limited to the high altitudes by the low temperature.

A number of ants seem to be able to thrive in cultivated fields although the top soil may be broken up several times every summer. A few are listed below:

Monomorium minimum Buckley
Pheidole dentata commutata Mayr
Pheidole vinelandica Forel
Crematogaster victma missouriensis Pergande
Aphenogaster treatae Forel
Dorymyrmex pyramicus Roger
Dorymyrmex pyramicus flavus McCook
Iridomyrmex pruinosus analis André
Prenolepis imparis Mayr
Prenolepis (N) *parvula* Mayr
Lasius niger americana Emery
Lasius niger neoniger Emery
Formica pallide-fulva schaufussi Mayr
Formica pallide-fulva schaufussi dolosa Wheeler

A number of ants are found in houses and sometimes may become serious enough to be classed as pests. Several are listed below:

Monomorium pharaonis Linnaeus
Monomorium minimum Emery
Solenopsis molesta Say
Crematogaster lineolata Say
Prenolepis imparis Say
Lasius niger neoniger Emery
Lasius niger americana Emery
Camponotus herculeanus pennsylvanicus DeGeer

Some of the species were well distributed over the state, while others seemed to be limited to certain areas. A list of those with state wide distribution are:

Ponera coarctata pennsylvanica Emery
Ponera trigona opacior Forel
Monomorium minimum Emery
Solenopsis molesta Say
Pheidole dentata commutata Mayr
Pheidole crassicornis Emery
Pheidole vinelandica Forel
Crematogaster lineolata Say
Crematogaster laeviuscula Mayr
Crematogaster victma missouriensis Pergande
Aphenogaster treatae Forel
Aphenogaster lamellidens nigripis Smith
Aphenogaster fulva Roger
Aphenogaster fulva aquia Buckley
Leptothorax curvispinosus Mayr
Leptothorax pergandi floridanus Emery
Dorymyrmex pyramicus Roger
Iridomyrmex pruinosus analis André
Prenolepis imparis Say
Prenolepis (N) *parvula* Mayr
Lasius niger americanus Emery
Lasius umbratus mixtus aphidicola Walsh
Formica pallide-fulva schaufussi incerta Emery
Camponotus castaneous americanus Mayr
Camponotus herculeanus pennsylvanicus DeGeer
Camponotus caryae decipiens Emery

Several species seemed to be confined to the eastern or highland section of the state. They are as follows:

Stigmatomma pallipes Haldeman
Proceratium silaceum Roger
Euponera gilva Roger
Eciton schmitti Emery
Eciton carolinensis Emery
Aphenogaster fulva aquia picea Emery
Aphenogaster tennesseensis Mayr
Myrmica brevinodis Emery
Myrmica scabrinodis fracticornis Emery
Myrmica punctiventris pinetorum Wheeler
Myrmica scabrinodis sabuleti Meinert
Leptothorax longispinosus Roger
Strumigenys creightoni Smith
Strumigenys dietrichi Smith
Tapinoma sessile Say
Brachymyrmex heeri depilis Emery
Lasius interjectus Mayr

Lasius claviger Roger
Formica sanguinea rubicunda Emery
Formica pallide-fulva schaufussi Mayr
Formica subaenescens Emery
Camponotus herculeanus pennsylvanicus ferrugineus Fabr
Camponotus caryae Fitch

Two species appeared to be limited to the Nashville Basin, namely:

Crematogaster opaca depilis punctulata Emery
Leptothorax (D) pergandei Emery

The following seem to be limited to the Mississippi Embayment region:

Aphenogaster texana carolinensis Wheeler
Formica pallide-fulva succinea Wheeler
Camponatus caryae rasilis pavidus Wheeler

Those found on the high mountain peaks are:

Stigmatomma pallipes Haldeman
Ponera coarctata pennsylvanica Emery
Crematogaster lineolata Say
Aphenogaster fulva Roger
Aphenogaster fulva aquia Buckley
Aphenogaster fulva aquia picea Emery
Myrmica scabrinodis sabuleti Meinert
Tapinoma sessile Say
Lasius niger americanus Emery
Lasius umbratus mixtus aphidicola Walsh
Formica sanguinea rubicunda Emery
Formica fusca subaenescens Emery
Camponotus herculeanus pennsylvanicus DeGeer
Camponotus caryae Fitch

Certain species prefer the moist shady forests; following is a list of that type:

Stigmatomma pallipes Haldeman
Proceratium silaceum Roger
Euponera gilva Roger
Ponera coarctata pennsylvanica Emery
Leptothorax curvispinosus Mayr
Strumigenys creightoni Smith
Strumigenys dietrichi Smith
Strumigenys rostrata Emery
Trachymyrmex septentrionalis obscurior seminole Wheeler
Brachymyrmex heeri depilis Emery
Formica fusca subaenescens Emery
Camponotus castaneus americanus Mayr
Camponotus herculeanus pennsylvanicus ferrugineus Fabr.

Several species prefer open situations, clearings or the borders of woods. Examples of those are:

Ponera trigona opacior Forel
Eciton schmitti Emery
Eciton carolinensis Emery
Monomorium minimum Buckley
Pheidole morrisi Forel
Pheidole tysoni Forel
Pheidole crassicornis Emery
Crematogaster laeviuscula Mayr
Crematogaster victma missouriensis Pergande
Aphenogaster treatae Forel
Aphenogaster fulva aquia Buckley
Aphenogaster tennesseensis Mayr
Leptothorax pergandei Emery
Dorymyrmex pyramicus flavus McCook
Dorymyrmex pyramicus Roger
Prenolepis imparis Say
Prenolepis (*N*) *parvula* Mayr
Lasius niger neoniger Emery
Lasius interjectus Mayr
Formica pallide-fulva schaufussi incerta Emery

Some species are found either in dense shade or in open situations. This type includes the following:

Myrmecina gramnicola americana Emery
Solenopsis molesta Say
Pheidole dentata commutata Mayr
Crematogaster lineolata Say
Aphenogaster lamellidens nigripis Smith
Aphenogaster fulva Roger
Aphenogaster fulva aquia picea Emery
Aphenogaster texana carolinensis Wheeler
Leptothorax longispinosus Roger
Leptothorax pergandei floridanus Emery
Tapinoma sessile Say
Lasius niger americanus Emery
Lasius umbratus mixtus aphidicola Walsh
Formica pallide-fulva schaufussi Mayr
Camponotus caryae rasilis pavidus Wheeler

There are several species that live in trees and get most of their food from insects working on the trees. This food is in the form of honey dew secreted by the insects, some of the species that belong to this group are:

Crematogaster lineolata Say
Crematogaster laeviuscula Mayr
Crematogaster laeviuscula clara Mayr
Leptothorax longispinosus Roger

Leptothorax curvispinosus Mayr
Camponotus herculeanus pennsylvanicus DeGeer
Camponotus caryae Fitch
Camponotus caryae decipiens Emery
Camponotus caryae rasilis Wheeler
Camponotus caryae rasilis pavidus Wheeler
Colobopsis mississippiensis Smith

A few species live in the ground but climb trees to forage for honey dew. They are:

Camponotus castaneus americanus Mayr
Formica fusca subaenescens Emery
Formica fusca subsericea Say
Formica pallide-fulva schaufussi incerta Emery
Formica pallide-fulva nitidiventris fuscata Emery
Formica pallide-fulva schaufussi dolosa Wheeler
Formica pallide-fulva succinea Wheeler
Lasius niger americanus Emery
Dorymyrmex pyramicus Roger
Dorymyrmex pyramicus flavus McCook

Two species, *Trachymyrmex septentrionalis obscurior seminole* Wheeler and *Dorymyrmex pyramicus flavis* McCook, were very common ants in the Mississippi Embayment region and were collected only in this region by the writer. Dr. C. H. Kennedy took these species in the bottom land of Townsend Valley, east of the Chilhowie Range. The valley is protected on the north and west by mountains and the temperature is higher than in locations without this protection from the west and northwest storms. This fact probably explains the presence of these species in East Tennessee.

DETAILED NOTES ON INDIVIDUAL SPECIES

Family Formicidae

Subfamily **Ponerinae**

Genus **Stigmatomma** Roger

Stigmatomma pallipes Haldeman

Typhlopone pallipes Haldeman, Proc. Acad. Nat. Sc. Phila., 2: 54, 1844.

Although very rare in all other sections of the state, this ant was common on the top of the high mountain peaks near Greenville. They were found nesting both in exposed and shady situations. The nests were in the ground and were covered by a stone or rock. This species was taken once in the valley near Tusculum College.

W. W. Wheeler gives the range of this ant from eastern Canada to eastern Texas. For a description of the ant and of its habits and nests see Wheeler's "Habits of Ponera and Stigmatomma," Biological Bulletin, Vol. 2, No. 2, pp. 43–69, 1900.

The reason this species is so common on top of the high mountains is probably due to the fact that these mountain peaks are in the fog belt and the humidity is high at all times. The one collection made in the valley was on a steep north slope in a very dense and damp woods.

Dr. C. H. Kennedy says that this species is common in northern Ohio, in flat, moist woods. Thus it appears that the degree of moisture is the factor that limits the distribution of this species.

Localities: Tusculum College, Cold Spring, Laurel Bald and Graystone Mountains, all near Greeneville.

Genus **Sysphincta** Roger

Sysphincta pergandei Emery

Sysphincta pergandei Emery, Zool. Jahrb. Syst., 8: 264, 1895.

Only one specimen of this rare ant was found. It was taken under a large, deeply imbedded rock at the foot of Graystone Mountain near Greenville.

Wheeler lists this ant from the Atlantic States and M. R. Smith has it in his list for Mississippi. It has been collected in southern Ohio (Wesson, Kennedy and Schramm collections). From the literature it seems to be very rare everywhere.

It is probably much more common but is a subterranean ant that is found only accidentally as there are no surface indications of its nests.

It can be easily recognized by the tip of the gaster being strongly deflected forward.

Locality: Graystone Mountain, near Greeneville.

Genus **Proceratium** Roger

Proceratium silaceum Roger

Proceratium silaceum Roger, Berlin, entom. Zeitschr., 7: 172, 1863.

This species was collected only in the Tennessee Valley. It seems to prefer well rotted logs or stumps in very shady woods. In every case the wood was decayed to a stage where it could be easily pulled apart by the hands. The ants are very slow moving and the colonies rather small; the largest colony collected consisted of 21 specimens.

According to Wheeler the range of this ant is the Atlantic States, but it is also listed by M. R. Smith from Mississippi and it has been collected in southern Ontario, northern and southern Ohio and in Missouri (C. H. Kennedy collection).

Since the nests are in wood that is decayed almost to powder, it was impossible to determine much about the structure of the nest because it was always destroyed before the ants were noticed.

Tennessee is evidently close to the southern limit of its distribution. It is rather common in the Northern States and it seems apparent that temperature is the controlling factor in the distribution of *silaceum*.

Localities: Tusculum College; Cold Spring Mountain, near Greeneville.

Genus **Euponera** Forel

Euponera gilva Roger

Ponera gilva Roger, Berlin, entom. Zeitschr, 5: 170, 1863.

This species was taken only twice, both collections were made near Tusculum College. The nests were always in well rotted logs. The ants are very timid and hide at the first opportunity after being disturbed. They appear at first sight much like *Proceratium*.

It is listed from "North America," by Wheeler. The writer was unable to find it listed in any of the Northern States lists and only from Mississippi and Tennessee in the south.

Locality: Tusculum College. (Also Kennedy at Montvale Springs.)

It was taken in very damp situations each time, and the decayed wood was well saturated.

For description of this ant see "Notes on *Euponera gilva* (Roger)," by Wm. S. Creighton and George S. Tullock, Psyche, Vol. 37, No. 1, pp. 71–79, 1930.

Genus **Ponera** Latreille

Ponera coarctata Latr. subsp. **pennsylvanica** Buckley

Ponera pennsylvanica Buckley, Proc. Entom. Soc. Phila., 6: 171, 1866.

This species is one of the very common ants of the state, being found on every collecting trip. It seems to be equally as common on the tops of the mountains, at an elevation of 6,000 ft., as any other situation. It nests in the ground as well as in wood. The nests in the ground are always under rocks or stones, and when nesting in wood it is generally found in the logs that are well decayed.

It is reported from Canada, North Eastern States, Kansas, Illinois, Florida, Mississippi, and North Carolina.

Wheeler says they prefer open and dry situations, but I have taken them in stumps in very dense woods at Ripley, Tenn.

For further data on their habits see Wheeler's "Habits of Ponera and Stigmatomma," Biological Bulletin, Vol. 2, No. 2, pp. 43–69, 1900.

Localities: Tusculum College, Mosheim, Greeneville, Morristown, Chuckey, Ripley, Slabtown.

Ponera trigona Mayr var. **opacior** Forel.

Ponera trigona Mayr var. *opacior* Forel, Trans. Ent. Soc. London, p. 363, 1893.

Although not common, this ant is distributed widely in the state, only seeming to be absent on the tops of the mountains. It was taken on the dry ridges at an elevation of 2,800 ft. Its nests were found both in the ground under rocks, and in logs or stumps. This variety is much more timid than the subsp. *pennsylvanica* and as soon as the nest is disturbed, hide under the first object available. It is found where there is plenty of moisture.

Type locality: Texas. Tennessee seems to be the farthest point north from which it has been reported.

This is a southern form of *Ponera* and temperature must be the limiting factor in its distribution.

For habits and nests see Wheeler's "Habits of Ponera and Stigmatomma," Biological Bulletin, Vol. 2, No. 2, pp. 43–69, 1900, and "Ants of the Genus Ponera in America North of Mexico," by Smith. Annals Ent. Soc. Amer., Vol. 29, No. 3, pp. 420–430, 1936.

Localities: Tusculum, Johnson City, Brownsville, Princeton, Murfreesboro, Nashville.

Subfamily **Dorylinae**

Genus **Eciton** Latreille

Eciton schmitti Emery

Eciton schmitti Emery, Jahrb., Abth. f. Syst., 8: 258–259, 1894.

This species was collected by Dr. C. H. Kennedy at Montvale Springs, near Maryville. The ants were scattered through a well decayed log in which there was a nest of *Aphenogaster* and *Lasius*.

Wheeler lists this species "Texas to Missouri and Colorado" and also from N. Carolina. M. R. Smith reports it from Mississippi.

It appears to be a southern form and although it may be more widely distributed than reports show it is probably absent from the northern states because of low temperature.

Locality: Montvale Springs, near Maryville.

Eciton carolinensis Emery

Eciton carolinensis Emery, Zool. Jahrb., 8: 259–260, 1895.

This ant was collected only in East Tennessee. It was most often taken on the stony hillsides or a few hundred feet above the base of the mountains where rocks were numerous. *Carolinensis* was never seen above ground and it is the writer's opinion that they do most of their foraging at night and perhaps, as some species of *Eciton*, never come to the light. One colony found late in the fall was very large, probably numbering about 50,000 workers.

The type locality is North Carolina. M. R. Smith gives its range as the Gulf and South Eastern States to North Carolina at least. North Carolina and Tennessee are probably very close to the northern limit of its distribution. Here again temperature appears to be the factor limiting distribution, because north of its range all the other factors except high temperature are present.

For a description of the interesting habits of the species close to *carolinensis*, see Chapt. 15 of "Ants," by W. M. Wheeler, Columbia University Press.

Localities: Tusculum College, Graystone Mountain, Cold Spring Mountain, Walkertown. Townsend, a nest with queen by Kennedy.

Subfamily **Myrmecinae**

Genus **Myrmecina** Fabr.

Myrmecina graminicola Fabr. subsp. **americana** Emery

Myrmecina latreilli subsp. *americana* var. *brevispinosa* Emery, Zool. Jahrb. Abth., of Syst., 8: 271, 1894.

Although not common this ant was taken in the eastern, central and western portions of the state. It was found nesting in the ground under rocks and in logs, and with few exceptions it was taken in very moist situations.

It is recorded from the North Eastern States, North Carolina and Illinois. It does not seem to be abundant anywhere in the United States.

This timid and slow moving ant has the interesting habit of feigning death when disturbed. Its nests in logs are generally in the center of the log where there is plenty of moisture. The colonies are small, always under 25 workers.

This is a northern form and North Carolina is probably its southern limit of distribution. The two nests taken in the Mississippi Embayment region were in large damp logs in very dense woods. Obviously temperature is the factor determining its distribution.

Localities: Tusculum, Cold Spring Mountain, Tiptonville, Ripley, Murfreesboro.

Genus **Monomorium** Mayr

Monomorium pharaonis Linnaeus

Formica pharaonis Linnaeus, Syst. Nat. 2, p. 963.

One collection of this ant was made at Ripley, Tenn. It was found running on the wash stand in a hotel room.

Wheeler says about this species, "It lives only in houses, warehouses, ships, etc., and has been carried to the different seaports of the globe from its original home in the warmer regions of the Old World." In the paper, "The Ants of Victoria County, Texas," by J. D. Mitchell and Dwight Pierce, Proc. Ent. Soc. of Washington, Vol. 14, pp. 67–76, 1912, the following is said about *pharaonis*, "This introduced ant has not only been a bad pest in the house, but has also been found nesting in the woods under bark of pecan and elm logs and also under the bark of a live pecan tree (Mitchell). This species has been taken attacking the immature stages of the boll weevil (W. W. Yothers).

It is evidently widely spread in the United States.

Locality: Ripley.

Monomorium minimum (Buckley)

Myrmica (*Monomarium*) *minima* Buckley, Proc. Ent. Soc. Phila., pp. 335–350, 1967.

With the exception of the highest mountain peaks this ant was found widely distributed throughout the state. In the Nashville region it is especially common. It builds its nests both in the ground and in stumps and logs. The nests in the ground are generally under a rock or stone but in some cases it opens to the surface without a covering.

One interesting fact concerning this species is the fact that each colony of considerable size may have many nest queens. Some nests were investigated that contained as high as 12 to 15 nest queens.

Wheeler gives its distribution as Atlantic States, Southern States and Texas. It is reported by Wm. P. Hayes in "A Preliminary List of the Ants of Kansas." So its distribution probably includes the middle west also, and it has been reported recently from the Pacific Coast.

This little black ant is a common house-infesting species in Tennessee, and not only is fond of sugar, jams and jellies, but will also eat meat, butter and greasy foods.

Localities: Tusculum, Morristown, Chuckey, Tiptonville, Ripley, Murfreesboro, Nashville.

Genus **Solenopsis** Westwood

Solenopsis molesta Say

Myrmica molesta Say, Bost. Soc. Journ. Nat. Hist., 1: 290, 1836.

This is a very common ant in all of Tennessee with the exception of the very tops of the highest mountain peaks. It was taken a few times at 5,000 ft. elevation.

It nests either in wood or the ground. Many times it nests in the walls separating the galleries of the formicaries of larger ants and steals food and even devours the larva and pupae of the other ants. It nests either in open or shady situations.

It is reported from the North and Eastern States by Wheeler and from South Carolina by Smith. South Carolina seems to be its southern limit of distribution.

For notes on habits and nests of this ant see "The Ants of New Jersey," by Wheeler. American Museum of Natural History, Vol. 21, Art. 33, pp. 371–403, 1905.

They were not found on the tops of the high mountains due, perhaps, to the fact that these peaks are within the fog zone and the ground is always very moist. They prefer open dry situations and moisture along with temperature is without a doubt the factors that limit its distribution.

Localities: Johnson City, Graystone Mountain, Cold Spring Mountain, Tiptonville, Ripley, Brownsville, Murfreesboro, Nashville, Slabtown.

Genus **Pheidole** Westwood

Pheidole morrisi Forel.

Pheidole morrisi Forel, Comptes-rendus, Soc. Entom. de Belgique. Seance du 6 fevrier, 1886.

Only three nests of this *Pheidole* were found. One nest was collected at Tiptonville in the Mississippi Embayment region and two in the Tennessee Valley. Its nests are built in the open and are very easy to locate, so on this account the writer believes that this species is rather rare in the localities collected over.

It is reported from Texas, Florida, North and South Carolina, New Jersey and southern New York.

It prefers pure sand for its nesting site according to Wheeler, and from other literature they are always found in sandy soil. The col-

lections made in Tennessee were both in very sandy loam and each had constructed a mound, one of which was about four inches high and ten inches across.

The workers and soldiers are very vigorous, rushing out when the nest is disturbed and attacking the forceps and the collector's hands, giving very noticeable bites. The nest extends at least two feet into the ground.

It appears that in the case of ***morrisi*** the substratum is an important factor in its distribution. Since the range of temperature, as well as rainfall and other factors, between Florida and New York is very wide, the substratum seems to be the only factor which is constant.

Localities: Graystone Mt., Cold Spring Mt., Tiptonville.

Pheidole dentata var. **commutata** Mayr

Pheidole dentata var. *commutata*, Zool. Jahrb. Syst., 8: 295, 1895.

This species is a very common form of Pheidole in all of Tennessee with the exception of the mountains. Unlike ***vinelandica*** it prefers the shady environment and with the exception of two nests it was always found in the woods. Of these two, one nest was in a meadow, the other in a soy bean field.

These are very active ants, but are not as pugnacious as ***morrisi***.

The species is listed from North and South Carolina, Mississippi, Florida and Texas. Tennessee seems to be the farthest north it has been reported, but no doubt will be found farther north, especially in the Mississippi Embayment region.

This is a southern form which probably is in the Tennessee Valley, due to the protection from severe winter weather afforded by the mountains to the north and west.

Localities: Greeneville, Tusculum, Knoxville, Morristown, Tiptonville, Ripley, Brownsville, Princeton, Murfreesboro, Slabtown.

For notes on their habits see "Ants of Victoria County, Texas," by J. D. Mitchell and W. Dwight Pierce, Proc. Ent. Soc. Washington, Vol. 14, p. 67, 1912.

Pheidole crassicornis Emery

Pheidole crassicornis Emery, Zool. Jahrb. Syst. 8: 289, 296, 1895.

Although far from common, this species was taken in all three sections of Tennessee. It was never found above the foot of the mountains. Nests were always in the ground but not always covered. A very large nest was taken in a potato patch at the foot of Coldspring Mountain near Greeneville, and the opening to the nest was surrounded by a low crater. However, the most of the nests are under rocks or logs.

This species is reported from North and South Carolina, Mississippi and other southern states.

It obviously is a form that requires high temperature, and Tennessee is perhaps very near its northern limit of distribution.

This ant can very readily be distinguished from the other ***Pheidoles*** by its distinctly flattened antennal scape.

Localities: Graystone Mt., Cold Spring Mt., Murfreesboro, Brownsville.

Pheidole tysoni Forel

Pheidole tysoni Forel, Annals de la Soc. Entom. de Belgique, 11: 384, 1901.

Dr. C. H. Kennedy collected this ant in the first cultivated area west of and below the Chimney Peaks in the Great Smoky Mountains. His field notes read, "Nest a scattered affair not over 2 inches deep but covering a square yard. Seeds stored in rooms the size of a sparrow egg. Brood in smaller chambers. Chambers connected by minute galleries."

Wheeler lists this ant from New York to North Carolina. It has been taken in southern Ohio (Kennedy collection).

This is a northern form. The collection made in North Carolina was near Bat Cave in Henderson County and there the altitude is more than 4,000 ft. Temperature is undoubtedly the factor which limits the distribution of the species and it is found in North Carolina due to the low temperature afforded by the altitude of the mountains.

Locality: Chimney Peaks, Gatlinburg.

Pheidole vinelandica Forel

Pheidole bicarinate race *vinelandica*, Comptes-rendus la Soc. Entom. de Belgique, Seance du 6 fevrier, 1886.

This is a very common species found in open situations in all parts of the state with the exception of the mountains. In some regions it was the most abundant species encountered. It was collected a great many times and was always taken in open fields with but one exception. One nest was found in a stump in a very open woods near Ripley.

It is recorded from Kansas, New Jersey, New York, North and South Carolina and Mississippi.

The colonies are never large (average about 125 workers) but are very numerous. The opening to the nest is generally surrounded with a low, regular crater. The runways extend from 10 to 18 inches down and pockets of these runways contain small seeds of various grasses, weeds, etc., which are used as food.

Localities: Tusculum, Johnson City, Cold Spring Mt., Jackson, Tiptonville, Ripley, Brownsville, Nashville.

Genus **Crematogaster** Lund

Crematogaster lineolata Say

Myrmica lineolata Say, Boston Jour. Nat. Hist., 1: 290, 1836.

This is a very common species in Tennessee from the high mountain peaks to the lowlands along the Mississippi. According to M. R. Smith they range throughout all parts of the United States.

They seem to prefer nesting in wood but were found under stones several times. There is a tendency in this ant to build carton-like structures in their nests.

They were very scarce in the moist situations and it appears that they prefer a dry habitat.

In Wheeler's paper on "Habits of the Tent Building Ant," Bulletin American Museum Natural History, Vol. 22, pp. 1–18, 1906, can be

found examples of construction of the "cow sheds," characteristic of this ant.

Localities: Tusculum, Graystone Mt., Chuckey, Jackson, Brownsville, Princeton, Laurel Bald Nt.

Crematogaster lineolata var. **cerasi** Fitch

Myrmica cerasi Fitch, Trans. N. Y. State Agri. Soc., 14: 835, 1854.

This was taken only in the Cedar Glades near Nashville. Wheeler gives the North Atlantic States as the range of this ant, and it has been reported from Illinois by Miss Talbot.

This is a northern type of *Crematogaster* and probably Tennessee is about the southern limit of its distribution.

It was found nesting in a log and its nest appeared much as that of *lineolata*.

Locality: Nashville.

Crematogaster leviuscula Mayr

Crematogaster leviuscula Mayr, Verhl. k. k. Zool. bot. Gesell. Wein, 20: 993.

Although rather rare, this species is widely distributed in the state. It was collected once in the Mississippi region, once in the Nashville Basin and twice in East Tennessee. It was not taken on the mountains.

It is reported from North Carolina, Mississippi and Texas. It evidently is a southern form with Tennessee perhaps marking its northern limit of distribution.

It feeds on honey dew and there is generally a line of the workers moving up and down a tree in the vicinity of the nest, going for and carrying back this material. Wheeler states that he has found this species nesting in the galls of the *Cynipid, Holcuspis cinerosus*, on oak in Texas. Most all the Crematogasters are fond of honey dew and the distribution may depend on the distribution of the insect they attend, and it appears that temperature must also be a factor in the distribution.

Localities: Nashville, Tusculum, Cold Spring Mt., Ripley.

Crematogaster leviuscula var. **clara** Mayr

Crematogaster leviuscula var. *clara* Mayr, Verhl. k. k. Zool. bot. Gesell. Wien, 20: 993.

A great number of these ants were found running up and down a large tulip tree on the Tusculum College Campus. Although the region was searched closely for the nest it could not be found, and no doubt it was in a decayed portion of the tulip tree some 20 feet above the ground. It differs from *leviuscula* in that it is larger and the head, thorax, pedicle and appendages are a yellowish red color.

It is reported from Mississippi, Kansas and Texas. It has similar food and nesting habits as *leviuscula*. This is a southern form also and what applies to *leviuscula* probably would apply to this variety.

Locality: Tusculum.

Crematogaster opaca depilis var. **punctulata** Emery

Crematogaster punctulata Emery, Zool. Jahrb., Abth. f. Syst., 8: 287, 1894.

Only one nest of this *Crematogaster* was taken. It was located in a stump in the Cedar Glades near Nashville. Wheeler lists it in his Ants of North America "Colorado to Texas" and M. R. Smith reports it from Florida.

This appears to be a variety far out of its natural range and may be due to the fact that the region of the Cedar Glades is limestone with underground drainage which makes for a very dry area, approaching perhaps the dry area of Texas and the sandy well drained areas of parts of Florida. Another explanation might be that if this variety attends plant lice, as a great many of the *Crematogasters* do, the plant lice attended might be in these Cedar Glades and not in the surrounding territory.

The nest looked much as the nest of *lineolata*.

Locality: Nashville.

Crematogaster victma subsp. **missouriensis** Pergande

Crematogaster victma subsp. *missouriensis* Pergande (Emery), Zool., Abth., f. Syst., 8: 287–288, 1894.

Although taken in the eastern, central and western portions of the state this ant was far from common. It was found nesting in the ground in every case, and in locations where there was good drainage. Nests were found both in sand and clay loam and always in open situations. They are very shallow and the colonies were small, not over 75 workers in a colony. The workers are very slow in their movements and when exposed to the light seem to be blinded.

M. R. Smith reports them from South Carolina and Mississippi, and Wm. P. Hayes from Kansas.

Localities: Tusculum, Chuckey, Jackson, Nashville.

Genus **Stenamma** Westwood

Stenamma brevicorne subsp. **diecki** Emery var. **impressum** Emery

Stenamma westwoodi subsp. *diecki* Emery var. *impressum* Emery, Zool. Jahrb. Abth. f. Syst. Bd., 8: 298, 1894.

This ant was collected several times by Dr. C. H. Kennedy near Indian Gap, at the top of the Great Smokies. The nests were found both in the ground under stones and in rotting wood. The altitude at Indian Gap is around 5,200 feet.

This species is listed by Wheeler from New York and Vermont.

Here is another species whose range is far to the north, but due to the low temperature provided by the altitude seems to be, at least in this region, rather common.

Locality: Gatlinburg.

Genus **Aphenogaster** Mayr

Aphenogaster treatae Forel

Aphenogaster treatae Forel, Comptes-rendus de la Soc. Entom. de Belgique. Séance du 6 fevrier, 1886.

Although this species is not very common, it is widely distributed in the state, being taken in the eastern, central and western parts.

It evidently is adapted to a wide variety of habitats, since it has been reported from Connecticut, Ohio, Illinois, Kansas, North and South Carolina, New Jersey, New York and Mississippi.

There seems to be a difference of opinion among the different collectors as to the habits of this species. Davis and Bequaert in their list of the ants of Staten Island and Long Island, N. Y., give their nesting place as in the sand in open woods. This in part is the observation of the writer in regard to those taken in Tennessee, in every case they were either in open fields or in very open woods. W. M. Wheeler and M. R. Smith agree that they nest in the shade. Of those taken in Tennessee one-half or more of the colonies were taken in oak stumps which is rather interesting in view of the fact that they are mentioned by the other collectors as nesting in the ground, and Wheeler in "The Ants of North Carolina" says, "never in logs."

The nests in the stumps are much like that of *fulva* or *picea*, while those in the ground have a small crater with the pellets of material from the nest scattered away from the entrance to a distance of 10 to 12 inches. The nest extends into the ground some 12 or 18 inches, with brood pockets very numerous near the top of the soil.

Perhaps the temperature itself or its effect on the amount of moisture is the factor which causes this species to build in some localities in the open and in others in the shade.

Localities: Ripley, Brownsville, Nashville, Tusculum.

Aphenogaster lamellidens var. **nigripes** Smith

Aphenogaster lamellidens var. *nigripes* Smith, Ent. News, 34: 308, 1923.

This variety differs from the species *lamellidens* in the color of its legs being distinctly darker. Their habits seem to be the same. With the exception of *fulva* this is the most common *Aphenogaster* in Tennessee. It is not found at an altitude above 2,500 ft. in the mountains but was taken in all three sections many times. It was collected in many types of forests and subsoils and with one exception it was always taken in logs or stumps. The exception was a nest in the base of a brick chimney at the writer's home.

The species *lamellidens* is reported from South and North Carolina, southern Ohio, and New Jersey. W. M. Wheeler reports *lamellidens* nesting in sand in New Jersey (evidently near its northern limit of distribution) while everywhere else it is reported nesting in wood. The absence of this ant in the mountains seems to be due to low temperatures because it was found in many types of forests, subsoil, in open and shady situations as well as wet and dry situations.

Localities: Mosheim, Graystone Mt., Cold Spring Mt., Tiptonville, Brownsville, Princeton, Murfreesboro, Slabtown, Tusculum.

Aphenogaster fulva Roger

Aphenogaster fulva Roger, Berlin, Entom. Zeitschr., 7: 190, 1863.

Fulva is another species which, though not common, has a very wide range of distribution in the state. It was taken along the

Mississippi River and on top of the high peaks of the Smokies, in dense forests and in open grassy fields, in logs and under rocks, in sand and in clay. They seem to be adapted to most any environmental conditions prevailing in Tennessee.

They are reported from South and North Carolina, Ohio, New Jersey, Illinois, Mississippi and Connecticut.

Its nests, both in wood and in the ground, are very similar to *aquia*.

Localities: Chuckey, Cold Spring Mt., Ripley, Brownsville, Laurel Bald Mt., Tusculum, Slabtown, Tiptonville.

Aphenogaster fulva subsp. **aquia** Buckley

Myrmica (*Monomarium*) *aquia* Buckley, Proc. Ent. Soc. Phila., p. 341, 1866.

This subspecies of *Aphenogaster* was taken on every collecting trip. Although it was not abundant on the high mountains it was taken there several times. In every other situation it was very abundant, and in some localities nearly every log had at least one colony nesting in it and there were many colonies nesting in the ground under rocks and stones.

Evidently this *Aphenogaster* is adapted to a wide range of ecological factors. It has been reported from Connecticut, Ohio, Illinois, North Carolina, Mississippi and Florida.

The nest in the log consists of many connecting runways and portions expanded for the brood. In the large logs it is generally located in the upper portion so that when the brood is brought up near the surface, generally just under the bark, it is exposed to a higher temperature. In the smaller logs where the heat can penetrate through it, the nest may be all through the log and extending into the ground beneath. The nests under rocks and stones do not extend far into the ground and the runways and brood pockets are arranged much as they are in the log. The brood is brought under the rock or stone where it is exposed to higher temperatures than in the ground.

Localities: Tusculum, Graystone Mt., Cold Spring Mt., Morristown, Chuckey, Brownsville, Murfreesboro, Slabtown, Ripley.

Aphenogaster fulva aquia var. **picea** Emery

Aphenogaster fulva aquia Buckley var. *picea* Emery, Zool. Jahrb. Syst., 8: 304, 1895.

The variety *picea* was taken only on the mountains at an altitude of 3,000 ft. or more and was most abundant on the top of the highest peaks at an altitude of about 6,000 ft. It was found both in logs and under rocks in the woods and in the grassy-bald situations. W. M. Wheeler reports it from Black Mountain, N. C., while M. R. Smith lists it as being collected from the ground in a dense patch of woodland at Rara Avis, Miss.

This is a common variety in Ohio, Illinois and Connecticut, found in shady woods and the writer believes that this is a northern form that is found in situations where the temperature is rather low and humidity high. In the mountains these conditions are present; therefore, the distribution in Tennessee is limited to the mountains. The colony found by M. R. Smith in Mississippi was in a dense woods and

the conditions of temperature and humidity might have been favorable, yet there is a possibility that this colony might be a different variety physiologically.

The nests of *picea* seem to be very much like *aquia* in all respects.

See Adele M. Fielde's paper, "Proceedings of Academy of Natural Science of Philadelphia," Vol. 53, pp. 425–449, pp. 521–544.

Localities: Cold Spring Mt., Laurel Bald Mt.

Aphenogaster fulva aquia var. **rudis** Emery

Aphenogaster fulva aquia Buckley var. *rudis* Emery, Zool. Jahrb. Syst., 8: 305, 1895.

This variety of *Aphenogaster* was taken only once. The nest was in a stump in a dense oak-elm woods. The workers were very timid and the colony was small. This ant seems to be rare as the only other collections for this territory are by W. M. Wheeler, who reports it from North Carolina, and C. H. Kennedy from Ohio. Until more collections are made little can be said about the ecological factors affecting its distribution or its habits.

Locality: Murfreesboro.

Aphenogaster texana var. **carolinensis** Wheeler

Aphenogaster texana var. *carolinensis* Wheeler, Bull. Amer. Mus. Nat. Hist., 34: 414, 1915.

The Mississippi Embayment region was the only region in which this variety was taken. It was not common, being collected only three times. It was taken by C. H. Kennedy under a stone at Montvale Springs near Maryville, Tenn., where the altitude is around 1,500 feet. Since *texana* is a common species farther south and this variety is reported from South Carolina and Mississippi but not from Florida, where *texana* is very common, it appears that this is the northern variety of a southern species. Temperature is probably the limiting factor of its distribution because it seems to be the only variable one.

It nests both in wood and in the ground. M. R. Smith says it is very common throughout South Carolina, nesting under stones, while those taken in western Tennessee were in rotting stumps. The nests in the wood were very similar in construction to those of *aquia*.

Localities: Tiptonville, Ripley.

Aphenogaster tennesseensis Mayr

Atta tennesseensis Mayr, Verhl. Zool. bot. Ges. Wien, 12: 743, 1863.

Although this species bears the name *tennesseensis* it is by no means common in that state. It was collected several times but only in the eastern part. It is much more common in Ohio, Illinois and other northern states. W. M. Wheeler says, "These aberrant females probably establish their colonies in nests of *Aphenogaster fulva*. At least *tennesseensis* is known to occur only in regions where *fulva* is unusually abundant and several mixed colonies of the two species, containing queens of *tennesseensis* only, have been recorded."

This is no doubt a northern form whose southern limit of distribution

is about Tennessee and North Carolina, where the altitude lowers the temperature to much like that of the northern states.

When living in unmixed colonies it always nests in rotting wood, and in the mountains was more often found under the bark of a standing dead chestnut.

Localities: Tusculum, Graystone Mt., Morristown, Chuckey.

Genus **Myrmica** Latreille

Myrmica punctiventris subsp. **pinetorum** Wheeler

Myrmica punctiventris subsp. *pinetorum* Wheeler, Bull. Amer. Mus., 21: 389, 1905.

Only one nest of this ant was taken. It was found in a small log in a dense oak-chestnut woods near Tusculum College. A few strays were taken at the base of Yost Mountain in a stump.

W. M. Wheeler in his "List of North American Ants," gives the range of this species as North Atlantic States. So far as can be determined this is the first time it has been reported south of New Jersey. Davis and Bequaert says, "This is the form of the pure sand of the pine barren region."

The nest was in a small log and the runway undoubtedly extended into the ground beneath, but the brood was in a small excavated place in the log.

This is a northern species which has been able to establish nests in this mountain area where temperatures do not go so high.

Localities: Tusculum, Greeneville.

Myrmica rubra L. subsp. **brevinodis** Emery

Myrmica rubra subsp. *brevinodis* Emery, Zool. Jahrb. Syst., 8: 312, 1895.

This species was collected by Dr. C. H. Kennedy at Montvale Springs near Maryville. The altitude there is around 1,500 ft. He also took it in Adams County, Ohio.

The nest taken at Montvale Springs was located between two flat rocks, with the walls of the nest composed of cedar needles and organic trash. The surface of the rocks where the nest was located was moist.

This species is listed by Wheeler from Colorado.

Until more collections of this ant are made little can be said about its biology.

Locality: Montvale Springs, near Maryville.

Myrmica rubra subsp. **scabrinodis** Nyl. var. **fracticornis** Emery

Myrmica rubra subsp. *scabrinodis* Nyl. var. *fracticornis* Emery, Zool. Jahrb. Syst., 8: 313.

This ant was collected by Dr. C. H. Kennedy in the first cultivated area below the west of Chimney Peaks and at Montvale Springs. The collection at Chimney Peaks was a stray ant, but a nest was taken at Montvale Springs. The nest was under a stone.

This species is rather common in the Northeastern States and this is the farthest point south it has been reported. Here as in many other cases it appears that due to the altitude afforded by the mountains, the temperature is favorable to its existence.

Localities: Chimney Peaks, Montvale Springs.

Myrmica scabrinodis var. **sabuleti** Meinert.

Myrmica sabuleti Meinert, Naturv. Afg. Dansk. Vid. Selsk., 5: 55, 1860.

This Myrmica also was taken only twice. One nest was found in a log along a mountain trail at an altitude of about 4,500 ft. and some strays were taken under a rock on top of Cold Spring Mountain which is over 6,000 ft. in height.

This ant is listed from the Northeastern States and New Jersey. As in the case of *pinetorum* no record can be found of this ant farther south than New Jersey.

It occurs in Tennessee due perhaps to the fact that the temperature on the high mountains would approximate that of the Northeastern States.

The nest was in the bottom of the log and the galleries extended into the ground.

Locality: Cold Spring Mountain.

Genus **Leptothorax** Mayr

Leptothorax longispinosus Roger

Leptothorax longispinosus Roger, Berl. Ent. Zeitschr., 7: 180, 1863.

This species *longispinosus* was collected only in the Tennessee Valley where it was by no means common. It was found nesting in logs and under the bark of dead, standing trees. As strays it was collected on leaves of low shrubs and weeds in the woods.

It is reported from Virginia, District of Columbia, New York, Connecticut and Illinois. From this it appears that Virginia and Tennessee is about the limit of its southern distribution and Illinois its western limit.

Longispinosus seems to be a northern form which prefers low temperature and dense shade. Their food is probably the same as that of *curvispinosus*.

Localities: Cold Spring Mt., Laurel Bald Mt., Tusculum, Walkertown.

Leptothorax curvispinosus Mayr

Leptothorax curvispinosus Mayr, Sitz. E. K. Akad. Wiss. Wien, 53: 1866.

This is the most common species of *Leptothorax* in the state. It was collected on nearly every collecting trip. Although not common on the mountains it was taken there several times. It is reported from the eastern states, Mississippi, South Carolina and Kansas.

It nests in hollow reeds, puffballs, nut shells, in logs, stumps and under rocks.

The workers are often found running on the leaves of weeds and low shrubs in the woods, and they are no doubt hunting for the insect secretion which drips from the trees on the shrubs and weeds beneath. The species *curvispinosus* does not seem to attend aphids.

Localities: Graystone Mt., Tusculum, Chuckey, Tiptonville, Brownsville, Murfreesboro.

Leptothorax (Dichothorax) pergandei Emery

Leptothorax (*D*) *pergandei* Emery, Zool. Jahrb. f. Syst., 8: 318, 323, 324, 1894.

The Nashville region was the only place where this ant was taken. One nest was located in a small decaying stick and in the ground under it, along Stone River at Murfreesboro. Several strays were taken in an open oak-hickory woods near Nashville.

This species has a rather wide range of distribution, being reported from Washington, D. C., North and South Carolina, Texas and Mississippi. It is no doubt a southern form with Washington, D. C., probably marking its northern distribution. Temperature appears to be the factor limiting its distribution. Smith says this is distinctly a ground nesting species.

Localities: Murfreesboro, Nashville.

Leptothorax (Dichothorax) pergandei subsp. **floridanus** Emery

Leptothorax (*D*) *floridanus*, Zool., Abth. f. Syst., 8, pp. 318–324, 1894.

This is another ant which is not common yet is distributed throughout the state with the exception of the high altitudes. It was much more abundant in the Mississippi Embayment region than anywhere else in the state. It is found in the woods generally, but in a few cases it was taken in open situations.

It is listed from Florida, North and South Carolina, and Mississippi. This ant resembles *pergandei* very closely, but while *pergandei*, according to M. R. Smith, is distinctly a ground-nesting species, *floridanus* was taken in stumps, logs and in one case from a hickory nut shell.

In this species, as in *pergandei*, we have a southern form whose distribution farther north than Tennessee or Kentucky is probably checked by low temperature. In the Mississippi Embayment region where the temperature runs higher than any other portion of Tennessee, it is common.

Localities: Graystone Mt., Morristown, Brownsville, Waverly, Murfreesboro, Nashville, Tusculum.

Genus **Strumigenys** F. Smith

Strumigenys (C) creightoni Smith

Strumigenys (*C*) *creightoni* Smith, Annals Ent. Soc. Amer., Vol. 24, pp. 705–706, 1931.

This species of *Strumigenys* was collected only in the Tennessee Valley. Only strays were taken, twice under the bark of stumps and once under a rock.

The type locality is Spring Hill and Mobile Ala., and it is reported from Mississippi and Virginia.

For description of this and following species of *Strumigenys* see "A Revision of the Genus *Strumigenys* of America, North of Mexico, Based on a Study of the Workers," by M. R. Smith. Annals of the Entomological Society of America, Vol. 24, No. 4, pp. 686–710, 1931.

Not enough collections were made of this ant to make any statement about its biology.

Localities: Tusculum, Chuckey, Cold Spring Mt.

Strumigenys (C) pulchella Emery

Strumigenys (C) pulchella Emery, Zool. Jahrb. Syst., 8: 327, 1895.

Only one nest of this very small ant was found. It was located in a stump at the base of Yost Mountain near Greenville.

The type locality is Washington, D. C., and Beatty, Penn., but is listed from Illinois, Mississippi, Alabama, Ohio and New York.

From a description of the ant, its habits and nest, see the publication mentioned under *Strumigenys creightoni.*

Locality: Greeneville.

Strumigenys (C) clypeata Roger

Strumigenys (C) clypeata Roger, Berlin, Ent. Ztg., p. 212, 1863.

One nest of this species was taken from a well decayed pine log in a pine thicket near Tusculum.

Type locality: Louisiana. It is also listed from Pennsylvania, North Carolina, District of Columbia and Mississippi.

The nest was destroyed before the ants were noticed. The log was decayed to a wet punky state. No other data is available on the habits of this species.

Locality: Tusculum.

Strumigenys (C) louisianae subsp. **laticephala** Smith

Strumigenys (C) louisianae subsp. *laticephala* Smith, Annals Ent. Soc. Amer., Vol. 24, pp. 690–691, 1931.

Only one nest of this ant was taken. It was located near Murfreesboro at the bottom of a small dead tree which I broke off some ten inches below the ground. The nest was in a small knot hole near the break and the colony consisted of a nest queen and 25 workers.

Type locality: Long View, Miss., and also reported from Alabama.

This is a southern form of Strumigenys and Tennessee, perhaps, marks its northern limit. Temperature here also is obviously the limiting factor in the distribution of the species.

For a description of this ant and its habits see publication mentioned under *creightoni.*

Locality: Murfreesboro.

Strumigenys (C) dietrichi Smith

Strumigenys (C) dietrichi Smith, Annals Ent. Soc. of Amer., Vol. 24, p. 698, 1931.

This species was taken several times in the Tennessee Valley only. In every case it was nesting in a log or stump.

Type locality: Lucedale, Mississippi. The writer is unable to find any other record of it.

These are very small and slow moving ants with very few workers in a colony, so are very easily overlooked; for this reason it is probable that this species is much more widely distributed than the records show.

Localities: Graystone Mt., Cold Spring Mt., Chuckey, Walkertown.

Strumigenys (C) rostrata Emery

Strumigenys (C) rostrata Emery, Zool. Jahrb. Syst., Vol. 8, p. 329, 1895.

This species was taken several times in the Tennessee Valley. The nests were in logs or stumps.

Type locality: Washington, D. C., also listed for Virginia, Maryland, New Jersey, California and Alabama.

Little is known about the habits of this species. They seem to always nest in wood.

Localities: Graystone Mt., Cold Spring Mt., Tusculum.

Genus **Atta** Fabricius

Atta (Trachymyrmex) septentrionalis subsp. **obscurior** var. **seminole** Wheeler

Atta :(Trachymyrmex) septentrionalis subsp. *obscurior* var. *seminole* Wheeler, Jr. N. Y. Ent. Soc., Vol. 19, p. 247, 1911.

This is a very common ant and was taken in the moist, densely shaded localities of the western Mississippi Embayment region. The nests are always in the ground and in the early spring can be located by a very characteristic crescent shaped pile of dirt which they have carried to the surface. This mass of earth may be as much as 18 or 20 inches away from the small opening to the nest.

Two strays collected by Kennedy in Happy Valley, Blount County, and many crescent mounds observed in bottom land cornfield at Townsend, Blount County. Both localities protected on north by Chilhowie Range, 2,000 ft. high.

The ants are very slow moving and timid and when disturbed hide under the first available leaf or particle of dirt.

This species is reported from Florida and Mississippi. Miami, Fla., is the type locality.

For a description of habits and nests of this ant see "An Annotated List of the Ants of Mississippi," by M. R. Smith. Entomological News, Vol. 35, 1924.

This is a southern form which requires a high temperature and plenty of moisture for the raising of the fungus which is their only article of food.

It will no doubt be found to occur in southern Kentucky and perhaps farther north along the Mississippi.

Localities: Ripley, Brownsville, Princeton.

Subfamily **Dolichoderinae**

Genus **Dolichoderus** Lund

Dolichoderus taschenbergi Mayr

Hypoclinea taschenbergi Mayr. Myrm. Beitr. in den Sitzungsber. der k. Akad. der Wissensch., Wien, 53, 1866.

One specimen of this ant was taken in a stump at the foot of Quaker Knobs near Chuckey, Tenn.

It is reported from Mississippi, Louisiana and North Carolina. M. R. Smith says that the habits of this ant are similar to those of *Dolichoderus mariae* Forel. Of these he says, "It constructs its nest in the soil at the base of broom straw grass, *Andropogon* sp., or more occasionally about the roots of small bushes. The colonies are very

large, consisting of thousands of individuals. Not only are the ants fond of honey dew but they also like insect food. The workers have a habit of crawling up and down trees in files."

In the Kennedy collection are specimens from southern Ohio and western New York.

Locality: Chuckey.

Genus **Dorymyrmex** Mayr

Dorymyrmex pyramicus Roger.

Dorymyrmex pyramicus Roger, Berlin, Entom. Zeitschr. 7: 160, 1836, n. 42.

The Lion ant, as it is commonly called, was taken but twice in the state, once at Jackson in the Mississippi Embayment region and the other time at the base of Cold Spring Mt. near Greeneville. Both collections were of strays. Dr. C. H. Kennedy collected it in a sandy bottom land cornfield at Townsend, east of Chilhowie Range.

It is listed from Mississippi, New Jersey, Kansas, Florida, North Carolina, New York, South Carolina and Texas. No doubt with more collecting this ant will be found in all parts of the state.

According to Smith the nests are built in sunny spots and have a small crater about the opening.

Localities: Cold Spring Mt., Jackson.

Dorymyrmex pyramicus var. **flavus** McCook

Dorymyrmex pyramicus var. *flavus* McCook, Comstock: Rep. Cotton-worm, 1879, p. 188, n. 2.

On the sandy hills and well drained situations of West Tennessee, this ant was rather common. On top of some of these low sandy hills near Jackson many hundreds of these craters could be counted. These hills have an open growth of tulip poplar on them and the ants were attending aphids in these trees.

This species is reported from Florida, North Carolina, Mississippi, South Carolina, Texas and Kansas. Dr. C. H. Kennedy collected it in sandy bottom-land cornfield at Townsend, east of Chilhowie Range. It is a southern form, but will probably be found farther north than Tennessee in the Mississippi Embayment region.

Since these ants are very fond of honey dew their distribution may be influenced by the distribution of the aphid they attend to some extent, but the temperature no doubt is the factor that excludes them from the northern states and the mountains.

Localities: Jackson, Brownsville, Princeton.

Genus **Tapinoma** Förster

Tapinoma sessile Say

Formica sessile Say, Boston Journal Nat. Hist., 1: 287, 1836.

Although this species is listed from most of the states from Canada to the Gulf, it is far from common in Tennessee and M. R. Smith also notes that it is very scarce in Mississippi. It was taken five times in Tennessee and each time in the Highland portion. It nests in the ground generally under a rock, small logs or bark of trees.

It appears to be a northern form that manages to survive in certain portions of the south where conditions are right. The writer found it only in very moist localities where no doubt the temperature approximated that of the northern states where it is very common.

For excellent descriptions of habits and nests of this ant see "The Biology of *Tapinoma sessile* Say, an Important House-Infecting Ant," by M. R. Smith. Annals Entomological Society of America, Vol. 21, pp. 307-329, 1928.

Localities: Tusculum, Cold Spring Mt., Chuckey.

Genus **Iridomyrmex**

Iridomyrmex pruinosus var. **analis** André.

Iridomyrmex pruinosus var. *analis* André, Rev. Ent., p. 148, 1893.

This variety of *Iridomyrmex* was found in all sections of the state with the exception of the mountains. It was especially abundant in the sandy region in the Mississippi Embayment region, where it was probably the most common species. In the Tennessee Valley it was abundant enough to be taken on every collecting trip, but was absent above the base of the mountains. It prefers the open sandy situations and with the exception of one nest found in a stump, it was found nesting in the ground. On very warm days these ants are exceptionally fast and are very difficult to pick up with forceps.

It has been reported from Mississippi, North and South Carolina and Kansas and from the sand dunes of southern Illinois.

The workers attend plant lice and scale insects and their distribution is probably dependent on the distribution of these insects.

Nests in the soil generally have a small crater around the entrance, but this is not always true. The nest in the stump looked very much like an abandoned termite nest had been taken over by the ants.

Localities: Tusculum, Graystone Mt., Tiptonville, Ripley, Brownsville, Murfreesboro, Nashville.

Subfamily **Camponotinae**

Genus **Brachymyrmex** Mayr

Brachymyrmex heeri Forel subsp. **depilis** Emery

Brachymyrmex heeri Forel subsp. *depilis* Emery, Zool. Jahrb. Syst., 7: 635, 1893.

With the exception of one locality this ant seems to be very scarce in the state. At the base and on the northern slope of Graystone Mountain near Greeneville, below 3,500 ft., it was abundant. It was collected also once on Short Mountain near Galbreath Springs.

It is reported from North Carolina, Florida, Ohio and Illinois, and Wheeler gives its range as northeastern United States.

This species attends root aphids and therefore is not often seen above ground. They were found nesting in decaying stumps and in the ground under stones. The nests in the stumps were generally located far into the stump in the punky, well rotted portion. Their runways no doubt contact with the root aphids for their food.

Their distribution evidently is determined to a great extent on the distribution of the root aphids which they attend.

Localities: Graystone Mt., Greeneville, Galbreth Springs.

Prenolepis imparis (Say)

Formica imparis Say, Boston Journ. Nat. Hist., 1: 287, 1836.

This ant is distributed throughout the state with the exception of the highest mountain peaks. In the valley it was very common. The nests are built in the soil and the ant seems to prefer clay, at least in Tennessee. Small pellets of earth are scattered around the entrance to the nest.

These ants are very fond of honey dew and other sweet material. The writer has taken them on watermelon bait when the gaster of the ant was so distended they had difficulty in running when disturbed.

They occur from New England to California, according to Wheeler.

For a complete description of their range, habits and nest see "The Ant *Prenolepis imparis* Say," by W. M. Wheeler. Annals Entomological Society of America, Vol. 23, pp. 1–26 (1930).

Localities: Tusculum, Graystone Mt., Johnson City, Morristown, Cold Spring Mt., Brownsville, Nashville.

Prenolepis subgen. **(Nylanderia)** Emery **parvula** Mayr

Prenolepis parvula Mayr, Verhl. Zool. bot. Ges. Wien, 20: 948, 1870.

With the exception of *Lasius niger* var. *americanus* this is the most common ant in Tennessee. It was not taken on top of the high mountains but everywhere else it was very plentiful. It nests in the ground, under stones, and also with no covering. In the latter case it makes a small crater. It was taken in logs and stumps both in open dry situations and in dense wet woods.

It is listed from most of the Northeastern States, North and South Carolina and Kansas.

It is very fond of honey dew and other sweets; discarded orange peel and watermelon rind will generally be covered with these and *Prenolepis imparis*.

Localities: Tusculum, Greeneville, Graystone Mt., Cold Spring Mt., Chuckey, Ripley, Brownsville, Princeton, Murfreesboro.

Genus **Lasius** Fabricius

Lasius niger Linnaeus var. **neoniger** Emery

Lasius niger var. *neoniger* Emery, Zool. Jahrb. Syst., 7: 639, 1893.

It was taken only twice, both times at Tusculum. It is not reported from farther south than Blue Ridge, N. C., and it is possibly a northern form, only reaching Tennessee and North Carolina due to the altitude.

Their habits and nests seem to be the same as for *americanus*.

Locality: Tusculum.

Lasius niger Linnaeus var. **americanus** Emery

Formica nigra Linn., Syst. Nat. Ed. 10a, 1: 580, 1758.

Although not as abundant as in the Northern States this is the most common ant in Tennessee. It was found on top of the mountains

well over 6,000 ft. high and in every other locality in which collections were made.

It is reported from New England, west to Kansas and south to southern South Carolina. M. R. Smith says it is not common in Mississippi and no doubt South Carolina and Mississippi is about its southern limit.

For data on nests and habits see "Habits and Behavior of Cornfield Ant, *Lasius niger americanus*," by Stephen A. Forbes, State Entomologist of Illinois. University of Illinois Agricultural Experiment Station, Bulletin No. 131.

Localities: Cold Spring Mt., Jackson, Brownsville, Laurel Bald Mt.

Lasius umbratus Nyl. subsp. **mixtus** Nyl. var. **aphidicola** Walsh

Formica mixta Nyl. var. *aphidicola* Walsh, Proc. Ent. Soc. Phila., p. 310, 1862.

This variety was not common but was taken twice on top of the mountains above 6,000 ft. and twice at Jackson, which is in the Mississippi Embayment area. It was found nesting in the ground, in logs and stumps. This variety is listed from Mississippi, northern Florida, and North Carolina as well as the Northern States.

The ants depend for food on the secretion of subterranean forms of plant lice and mealy bugs, and their distribution is perhaps determined in great part by the distribution of the insects which they attend.

Localities: Cold Spring Mt., Brownsville.

Lasius subgen. **(Acanthomyops) interjectus** Mayr

Lasius (*A*) *interjectus* Mayr, Verhl. Zool. bot. Ges. Wien, 16: 888, 1886.

The eastern portion was the only place in the state where *interjectus* was found but it probably occurs in other portions since it is reported from Mississippi and South Carolina. It is common in the Northeastern States.

It was found nesting in the ground in every case, either under a rock or log. M. R. Smith says of this ant, "The workers are fond of attending subterranean plant lice, mealy bugs, etc. The ants seem to shun light and are never seen on the surface unless unearthed or exposed."

Localities: Tusculum, Graystone Mt.

Lasius (Acanthomyops) claviger Roger

Formica claviger Roger, Berlin. entom. Zeitschr., 6: 241, 1862.

This species of *Lasius* was only taken three times, and each time was found nesting in the sand on the bank of the Nolichuckey River near Tusculum.

It is reported from the Northern States by Wheeler but is also listed from Florida, North and South Carolina, Kansas, Illinois and Mississippi. (M. R. Smith says it is exceedingly rare in the region about State College, Miss.)

This is a very common ant in the Northern States but grows less common to the South. It is found in the rather moist localities where the temperature is kept rather low.

Dealated females have been found under rocks during the winter and on the warmer days have been caught running around, according to Davis and Bequaert in their paper on "Ants of Staten Island and Long Island, N. Y." Bull. Brooklyn Ent. Soc., Vol. 17, No. 1, pp. 1–25, 1922.

Locality: Tusculum.

Genus **Formica** Latreille

Formica sanguinea subsp. **rubicunda** Emery

Formica sanguinea subsp. *rubicunda* Emery, Zool. Jahrb. Syst., 7: 647, 1893.

A large number of these ants were observed while they were on a raid for slaves, on the very top of Cold Spring Mountain which has an altitude of over 6,000 ft. This was the only time this ant was taken.

It is reported from Pennsylvania, New Jersey, North Carolina, Massachusetts, Connecticut, Michigan, Illinois, Colorado, Montana and Canada. So it is obvious that this species is a northern form which is able to exist as far south as Tennessee and North Carolina due to the temperature in the mountains approximating that of its range to the north.

The nest of this species is very similar to *subintegra*. An attempt was made to excavate the nest found but the number and size of the rocks beneath the ground surface made it impossible to do so.

For an interesting account of the foray of this species see Wheeler's work "On the Founding of Colonies by Queen Ants, with Special Reference to the Parasitic and Slave Making Species." American Museum of Natural History, Vol. 22, Article 4, pp. 33–105, 1905.

Locality: Cold Spring Mt.

Formica sanguinea subsp. **subintegra** Emery

Formica sanguinea subsp. *subintegra* Emery, Zool. Jahrb. Syst., 7: 648, 1893.

This ant was taken in the eastern and western parts of the state and it will probably be found to occur in most of the regions of Tennessee. In the eastern portion it was taken both in the Smoky Mountains and the Tennessee Valley. The collection in western Tennessee was of stray ants, the nest was not located.

It is listed from Illinois, Pennsylvania, New Jersey, New York, Connecticut, Massachusetts and Maine.

It nests in the ground, generally excavating under rocks or logs and, according to Wheeler, is fond of moving its nests from time to time.

They make raids on the nests of *Formica fusca* and other species and pillage the nest and carry off the pupae, which when grown to maturity act as "slaves" or "auxiliaries."

This is a northern form and Tennessee seems to be the farthest south it has been taken.

For a very interesting account of the slave making habit of the *sanguinea* see "Notice of a Foray of a Colony of *Formica sanguinea* Latr. upon a Colony of a Black Species of Formica, for the Purpose of Making Slaves of the Latter," by J. A. Allen, Proc. of the Essex Institute, Vol. 5, No. 1, pp. 1–3, 1866, and W. M. Wheeler's "The Ants

of Casco Bay, Maine, with observations on Two Races of *Formica sanguinea* Latreille." American Museum of Natural History, Vol. 24, Article 33, pp. 619–645, 1908.

Localities: Graystone Mt., Tusculum, Brownsville.

Formica pallide-fulva var. **succinea** Wheeler

Formica pallida-fulva var. *succinea* Wheeler, Bull. Amer. Mus. Nat. Hist., 20: 369, 1904.

This species was taken but twice, once in the Nashville region and the other time at Tiptonville in the Mississippi Embayment. The only nest found was in the ground at the edge of a dense woods. The opening to the nest, which was at least one inch in diameter, was much larger than that of any other form of *pallide-fulva* collected. The opening was surrounded by a crater 2 to 3 inches high. The nest extended beyond 2½ ft. into the ground.

Type locality is Austin, Texas; also reported from Oklahoma.

This is distinctly a southern form with Tennessee, perhaps, about its northern limit. Temperature appears to be the important factor in its distribution.

Localities: Tiptonville, Murfreesboro.

Formica pallide-fulva subsp. **schaufussi** Mayr

Formica schaufussi Mayr, Verhl. der. k. k. Zool. bot. Gesell. Wien. 1886, 11–12.

This species was taken several times but only in the Tennessee Valley. It prefers open situations for nesting, and the openings of the nests are surrounded with very little or no material, which differs from most of the *pallide-fulva*. It is very timid and when disturbed runs rapidly away leaving the larva and pupae.

It is listed from Ontario, Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, North Carolina, Indiana, Illinois, Wisconsin, and Mississippi.

For description of the ant and its habits see "A Revision of the Ants of the Genus Formica," Bulletin of the Museum of Comp. Zoology, Vol. 53, No. 10, 1913.

Localities: Knoxville, Graystone Mt., Tusculum.

Formica pallide-fulva subsp. **schaufussi** Mayr var. **incerta** Emery

Formica pallide-fulva schaufussi var. *incerta* Emery, Zool. Jahrb. Syst., 7: 655, 1893.

Of the *pallide-fulva* group taken in Tennessee this variety was by far the most common. It was not taken in the central portion of the state but will probably be found with more intensive collecting. It was not taken on the mountains due, perhaps, to the fact that it prefers open situations for nesting. It is widely distributed in the United States, being listed from Virginia, New Jersey, New York, Pennsylvania, Connecticut, Massachusetts, New Hampshire, Illinois, Wisconsin, Colorado and New Mexico.

In every case it was found nesting in open situations, especially corn and cotton fields. The opening to the nest is generally surrounded by a small crater.

While collecting in the region near Ripley, the writer happened to notice a colony of this ant whose nest had been covered with water due to heavy rains. The queen, and workers bearing the brood in their mandibles, were all clinging to a dead weed which extended above the water about two feet. The opening to the nest with its crater could be plainly seen through the two or three inches of water at the base of the weed.

Localities: Tusculum, Ripley, Tiptonville.

Formica pallide-fulva subsp. **nitidiventris** Emery var. **fuscata** Emery.

Formica pallide-fulva subsp. *fuscata* Emery, Zool. Jahrb. Syst., 7: 656, 1893.

Only one specimen of the ant was collected. It was found running on a tree in an open woods near Murfreesboro.

Type locality: Pennsylvania. Reported also for North Carolina, Georgia, New Jersey, New York, Massachusetts, Illinois, South Dakota, New Mexico and Ontario.

Wheeler says the following about this variety: "This ant nests only in woods, usually in hilly country and is much rarer than any other varieties or subspecies."

Locality: Murfreesboro.

Formica pallide-fulva schaufussi var. **dolosa** Wheeler.

Formica pallide-fulva schaufussi var. *dolosa* Wheeler, Bull. Amer. Mus. Nat. Hist. 20: 370, 1904.

Although this ant was taken several times it is far from common. It was taken only in the Tennessee Valley section, but will no doubt be found to occur throughout the state with the exception of the higher altitudes.

Wheeler says this is a distinctly southern variety of *schaufussi*. He lists it from Texas, Arkansas, Louisiana, Missouri, North Carolina and Georgia.

Its nesting habits are the same as for *incerta*.

Localities: Tusculum, Chuckey, Graystone Mt.

Formica fusca Linnaeus var. **subsericea** Say

Formica subsericea Say, Boston Journ. Nat. Hist., 1: 239, 1836.

Only one specimen of this *Formica* was taken. It is the common black *Formica* in the northern states, and obviously is rare in Tennessee. The specimen was taken at Tiptonville, which is near the Mississippi River. According to Wheeler it is the most abundant insect, next to *Lasius niger* var. *americanus*, in the eastern United States.

For information on its nests and habits see "A Revision of the Ants of the Genus Formica Mayr," Bulletin of Museum of Comp. Zoology, Vol. 53, No. 10, 1913.

Locality: Tiptonville.

Formica fusca var. **subaenescens** Emery[2]

Formica fusca var. *subaenescens* Emery, Zool. Jahrb. Syst., 7: 659, 1893.

Although this seems to be a northern form it was the most common form of *Formica* in east Tennessee. It was especially common on top of the high peaks of the Big Smoky Mountains. It was collected several times in the valley but the nests were always in very shady locations. It was not taken in the central or western portions of the state.

In this case it seems very evident that temperature must be the most important factor in the distribution of this ant. The altitude of the area in which it was found provides a temperature approximating that of its range to the north.

It is reported from Illinois, Maine, New Hampshire, Massachusetts, Connecticut, New York, Montana, Utah, South Dakota, Colorado and Canada.

It was found nesting in the ground under rocks in all but two cases. On top of Laurel Bald Mountain one nest was found in a log, and one in a stump.

Localities: Tusculum, Graystone Mt., Laurel Bald Mt.

Genus **Camponotus** Mayr

Camponotus castaneus Latreille

Camponotus castaneus Latreille, Hist. Nat. Fourm., p. 110, 11, 12 A. C. and D., 1802.

Only two specimens of this large beautiful ant were taken. One was brought to the writer by a resident of Greeneville, who said the colony was nesting in the sill of a porch. The other was picked up on a path on the campus of Tusculum College. It is listed from New Jersey, Illinois, New York, Connecticut, Florida, North Carolina and Ohio.

Wheeler says it nests in the ground under stones and logs in rather small colonies.

Localities: Greeneville, Tusculum.

Camponotus castaneus subsp. **americanus** Mayr

Camponotus americanus Mayr, Verhl. Zool. bot. Ges. Wien, 12: 661, 1862.

This subspecies of *Camponotus* was taken in all three sections of Tennessee, but was not taken on the mountains. In some sections it is very common, while in others it seems to be entirely absent. Especially in East Tennessee, in woods where drainage was good and where rocks were scattered about, there were many colonies. They seem to prefer clay soil, but will nest in other types. Dr. C. H. Kennedy took this ant as common in the west slope of the Chilhowie Range at an elevation of 1,000 ft. above the valley. Found under flat stones on moderately moist slopes.

[2]C. H. Kennedy's collections made at Indian Gap (5,000 ft.), Blount Co., have been named *lecontei*. See Annals Ent. Soc. Amer. 30 (3): 542–544, 1937.

It has a very wide distribution, being reported from Florida, South Carolina, North Carolina, New York, New Jersey, Connecticut, Ohio, Illinois and Mississippi. W. H. Wheeler says they range as far north as Massachusetts.

It usually builds its nests in the ground under a stone or rock. Dr. Mary Talbot in her paper on "Distribution of Ant Species in the Chicago Region," gives their nesting sites as logs and ground.

There seems to be no good reason for absence of this ant in the high mountains unless it can be attributed to too much moisture. The winter temperature is certainly not more severe than Massachusetts nor the summer temperature greater than Florida. The subsoil on the mountains is clay and it nests freely in clay in the valley. The rainfall and moisture, however, is greater on the mountains and perhaps this is the factor which limits their distribution to the lower altitude.

Localities: Tusculum, Knoxville, Brownsville, Nashville.

Camponotus herculeanus L. subsp. **pennsylvanicus** DeGeer

Formica pennsylvanica DeGeer, Mem. Serv. Hist. Insects., 3: 391, 1773.

The "Carpenter Ant" is found in all regions of Tennessee, from the highest mountains to the lowlands of the Mississippi. In some regions it is the most common ant encountered. It probably occurs in the whole area of the United States east of the Rockies. It is reported from Texas, Florida, North and South Carolina, Mississippi, Ohio, Illinois, New York, New Jersey and Connecticut. It seems to be adapted to a great variety of environmental factors.

It generally nests in logs or stumps in shady places, but often nests in standing trees that may be partially decayed. It is sometimes taken in logs that are in the open, thus it seems to be able to stand a great range of temperature. In a paper, "Notes on the Architecture and Habits of *Formica pennsylvanica*, The Pennsylvania Carpenter Ant," Rev. Henry C. McCook, Transactions of American Entomological Society, Vol. 5, there is an excellent description of nesting habits and views of the galleries. And in a paper also by Rev. H. C. McCook, "On the Vital Powers of Ants," in Proceedings American Entomology Society, December, 1876, is an account of his experiment in which he subjected the workers of *C. herculeanus pennsylvanicus* to extremes of temperature, both high and low, with no apparent harm to the ants.

Localities: Greeneville, Knoxville, Tusculum, Cold Spring Mt., Brownsville, Laurel Bald Mt., Nashville, Slabtown.

Camponotus herculeanus L. subsp. **pennsylvanicus** var. **ferrugineus** Fabr.

Formica ferruginea Fabricius, Suppl. Entom. Syst., 279, 1798.

This variety of *Camponotus* was taken only in the Tennessee Valley. It has been reported from Mississippi, New Jersey and Illinois. Wheeler states in regard to this variety, "It is apparently confined to the states east of the Mississippi River. Its habits are very similar to those of *pennsylvanicus*, but it seems to be much less abundant."

It was found nesting with one exception in logs or dead trees still standing. The exception was a nest under a rock and in digging for the runways it was found that they followed the roots of a maple tree, and in several places the root had been cut into for brood pockets.

If more intensive collecting is done in the other regions of the state, this variety will undoubtedly be found.

Localities: Greeneville, Chuckey, Cold Spring Mt., Tusculum.

Camponotus caryae Nyl. **caryae** Fitch.

Camponotus caryae (Fitch), Trans. N. Y. State Agri. Soc., 14: 855–859, 1855.

Only one nest of this ant was taken. However, stray workers were caught running several times in dense woods. It was not taken anywhere except in east Tennessee. The nest was in a partially dead oak tree near the top of Laurel Bald Mountain which has an altitude of better than 6,000 ft. The strays were taken in very dense oak-chestnut woods in the valley near Tusculum.

This ant is not often listed in the literature, but it has been reported from South Carolina, New York, Ohio, New Jersey and Connecticut.

Localities: Tusculum, Laurel Bald Mt.

Camponotus caryae var. **decipiens** Emery

Camponotus marginatus var. *decipiens* Emery, Zool. Jahrb. Abth. f. Syst., 7: 676, 1893.

Throughout the state this seemed to be the most common of the *caryae* group. Only one nest was ever found but it was collected in the eastern, central and western portions running on the ground or on vegetation. One nest was located in the porch of the writer's home but was not cut into.

It is reported from Indiana, Kansas, Colorado, Utah, South Carolina and Mississippi.

Since these ants usually build in galls of trees or in partially dead trees, environmental factors such as moisture, temperature, etc., are probably not as important as in the case of those which build their nests in the ground. Since they attend plant lice and also eat the secretions of oak trees, these factors are probably more important in their distribution.

The nest in the porch at Tusculum was in solid, cured wood, shown by material that the ants were carrying out during their excavation.

Localities: Tusculum, Brownsville, Murfreesboro.

Camponotus caryae subsp. **rasilis** Wheeler.

Camponotus caryae subsp. *rasilis* Wheeler, Jour. N. Y. Ent. Soc., 18: 227, 1910.

Only one specimen of this *Camponotus* was taken. It was found running on a log in a rather dense oak-chestnut wood. The nest was not located.

It is reported from Florida, Texas and Mississippi. M. R. Smith in his "List of the Ants of Mississippi," gives the following regarding its habits: "Nests are made in galls or in twigs of trees. Occasionally

the workers invade houses, showing a decided fondness for sweets, such as syrup, jams, sugar, etc."

Tennessee appears to be close to its northern limit of distribution and temperature is evidently the most important factor in its distribution.

Locality: Graystone Mt.

Camponotus caryae subsp. **rasilis** var. **pavidus** Wheeler

Camponotus caryae subsp. *rasilis* var. *pavidus* Wheeler, Jour. N. Y. Ent. Soc., 18: 228–229, 1910.

The Mississippi Embayment was the only region where this *Camponotus* was taken.

This variety has been reported from Florida and Mississippi and it is without much doubt a southern form and Tennessee or Kentucky is probably about the northern limit of its distribution. There is the possibility, however, that it will be found much farther up the Mississippi than these states.

It was found nesting in oak stumps. The workers are very cowardly and flee from the nest when it is disturbed.

Localities: Ripley, Brownsville.

Camponotus (Colobopsis) mississippiensis Smith

Camponotus (*C*) *mississippiensis* Smith, Psyche, 30: 83–86, 1923.

A single specimen of this ant was taken near Murfreesboro in June, 1935. It was running on the leaves of weeds bordering Stone River.

M. R. Smith says it is the most common species in the region of State College, Miss., and that it is found nesting in the twigs of white ash and in red oak galls.

The worker has been seen to feed on honey dew. It is a southern form and the writer believes that Murfreesboro marks the farthest point north it has been reported.

Since it is known to feed on honey dew, its distribution may be determined by the presence of the insect it attends. But temperature also certainly seems to be a factor.

For description of habits of *Colobopsis* see "The American Ants of the Subgenus Colobopsis," by Wheeler. American Museum of Natural History, Vol. 20, Art. 10, pp. 139–158, 1904.

Locality: Murfreesboro.

ANT DISTRIBUTION IN TENNESSEE

	No of Collections	300–2,000 ft.	2,000–5,000 ft.	Above 5,000 ft.	In Weed and Grass Stems	In Logs, Stumps	In dead wood of Standing Trees	With Crater	With Mound	Under Stones	In Ground	Oak-Hickory	Hemlock-White Pine	Oak-Pine	Oak-Chestnut	Tulip-Hemlock	Spruce	Lower Grass Land	High Grassy-Balds	Cedar Glades	Stray Ants only	Nest Taken
Stigmatomma pallipes	4	*		*						*	*				*	*					*	
Sysphincta pergandei	1		*							*	*											*
Proceratium silaceum	4	*	*			*								*	*							*
Euponera gilva	2	*		*		*						*	*		*	*	*				*	*
Ponera coarctata pennsylvanica	11	*	*	*		*				*	*	*	*		*	*	*				*	*
Ponera trigona opacior	7	*				*				*	*				*							
Eciton schmitti	1	*				*															*	
Eciton carolinensis	3	*	*							*	*	*		*	*							*
Myrmecina graminicola americana	7	*	*			*				*	*	*		*	*						*	
Monomorium pharaonis	1	Ripley		—In Hotel.																		*
Monomorium minimum	9	*	*			*				*	*	*		*	*			*			*	*
Solenopsis molesta	17	*	*			*				*	*	*		*	*			*	*		*	*
Pheidole morrisi	3	*							*			*			*			*				*
Pheidole dentata commutata	14	*				*			*	*	*	*			*			*				*
Pheidole crassicornis	5	*				*			*	*	*	*			*							*
Pheidole tysoni	1	*									*	*			*							*
Pheidole vinelandica	11	*				*			*		*	*						*				*
Crematogaster lineolata	11	*	*	*		*			*		*	*			*			*				*
Crematogaster lineolata cerasi	1	*				*																*
Crematogaster lineolata	4	*				*									*			*				
Crematogaster lineolata clara	1	*																			*	
Crematogaster lineolata clara	1	*					*														*	*
Crematogaster opaca depilis panchulata	4	*							*			*							*			*
Crematogaster vicina missouriensis	2					*						*	*									*
Stenamma brevicorne im pressum	5	*				*			*					*					*			*
Aphenogaster treatae	13	*					*							*	*							*
Aphenogaster lamellidens nigripes																						

Ant Distribution In Tennessee—(Continued)

	No of Collections	300-2,000 ft.	2,000-5,000 ft.	Above 5,000 ft.	In Weed and Grass Stems	In Logs, Stumps	In dead wood of Standing Trees	With Crater	With Mound	Under Stones	In Ground	Oak-Hickory	Hemlock-White Pine	Oak-Pine	Oak-Chestnut	Tulip-Hemlock	Spruce	Lower Grass Land	High Grassy-Bald	Cedar Glades	Stray Ants only	Nest Taken
Aphenogaster fulva	9	*	*	*		*				*	*	*		*	*	*	*		*			*
Aphenogaster fulva aquia	19	*	*	*		*				*	*	*	*	*	*		*	*	*			*
Aphenogaster fulva aquia picea	6			*		*				*	*	*		*	*				*			*
Aphenogaster fulva aquia rudis	1	*				*						*										*
Aphenogaster texana carolinensis	3	*				*						*										*
Aphenogaster tennesseensis	6	*	*			*								*	*							*
Myrmica punctiventris pinetorum	2	*				*								*	*							*
Myrmica rubra brevinodis	1	*									*				*							*
Myrmica rubra scabrinodis fracticornis	2	*		*							*				*							*
Myrmica rubra scabrinodis sabuleti	2			*							*			*	*							*
Leptothorax longispinosus	5	*	*			*	*							*	*							*
Leptothorax curvispinosus	10	*	*	*	*	*	*			*	*	*			*				*			*
Leptothorax (D) pergandei	2	*				*						*										*
Leptothorax (D) pergandei floridanus	9	*	*			*				*		*		*	*			*		*		*
Strumigenys creightoni	3	*				*				*	*	*			*							*
Strumigenys pulchella	1	*				*									*							*
Strumigenys clypeata	1	*				*								*								*
Strumigenys louisianae laticephala	1	*				*						*								*		*
Strumigenys dietrichi	4	*				*						*		*	*							*
Strumigenys rostrata	3	*				*								*	*							*
Trachymyrmex septentrionalis obscurior seminole	3	*						*			*	*										*
Dolichoderus taschenbergi	1	*				*								*							*	
Dorymyrmex pyramicus	2	*	*							*	*				*						*	
Dorymyrmex pyramicus flavus	3	*						*			*							*					*
Tapinoma sessile	5	*	*	*			*			*	*				*			*	*	*			*
Iridomyrmex pruinosus analis	9	*				*		*		*	*							*		*			*

Ant Distribution In Tennessee—(Continued)

	No of Collections	300–2,000 ft.	2,000–5,000 ft.	Above 5,000 ft.	In Weed and Grass Stems	In Logs, Stumps	In dead wood of Standing Trees	With Crater	With Mound	Under Stones	In Ground	Oak-Hickory	Hemlock-White Pine	Oak-Pine	Oak-Chestnut	Tulip-Hemlock	Spruce	Lower Grass Land	High Grassy-Balds	Cedar Glades	Stray Ants only	Nest Taken
Brachymyrmex heeri depilis	7		*			*				*	*		*	*	*	*						*
Prenolepis imparis	10	*	*							*	*		*	*	*			*		*		*
Prenolepis (N) parvula	17	*	*			*				*	*			*	*	*		*				*
Lasius niger neoniger	2	*						*		*	*				*			*				*
Lasius niger americana	6	*	*	*		*		*		*	*	*	*	*	*	*		*	*			*
Lasius umbratus mixtus aphidicola	4	*		*						*	*	*							*			*
Lasius interjectus	6	*	*							*	*			*	*			*				*
Lasius claviger	3	*								*	*				*							*
Formica sanguinea rubicunda	1			*							*								*		*	
Formica sanguinea subintegra	3	*								*	*	*		*	*							*
Formica pallide-fulva succinea	2	*									*	*									*	
Formica pallide-fulva schaufussi	4	*								*	*	*		*	*			*				*
Formica pallide-fulva incerta	6	*						*			*	*						*				*
Formica pallide-fulva nitidiventris fuscata	1	*										*									*	
Formica pallide-fulva schaufussi dolosa	4	*	*					*			*			*	*			*				*
Formica fusca subsericea	1	*																*			*	
Formica fusca subaenescens	9	*	*	*		*				*	*		*	*	*				*			*
Camponotus castaneus	2	*													*						*	
Camponotus castaneus americanus	7	*								*	*	*		*	*					*		*
Camponotus herculeanus pennsylvanicus	12	*	*	*		*	*	*				*	*	*	*	*						*
Camponotus herculeanus pennsylvanicus ferrugineus	5	*				*		*		*	*			*	*							*
Camponotus caryae	2	*	*				*							*	*							*
Camponotus caryae decipiens	6	*												*	*						*	
Camponotus caryae vasilis	1		*											*	*						*	
Camponotus caryae vasilis pavidus	3	*				*						*										*
Camponotus (C) mississippiensis	1	*																		*	*	

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SCIENTIFIC ILLUSTRATION, by JOHN L. RIDGWAY, pp. i-xiv and 1–173, 23 text figs, 22 plates with frontispiece in color. 1938. Published at Stanford University, California, by the STANFORD UNIVERSITY PRESS. Price $4.00. (Also Oxford University Press, and in London: Humphrey Milford.)

This is a review of the processes involved in scientific illustration from the first planning of the illustrations for a specific project, through the various methods of drawing, painting and photography, to the processes of reproduction used by the engraver and in some cases by the printer. Fortunately for the reader it is by an authority of broad experience. Ridgway is at present in charge of illustration for the California Institute of Technology and the Carnegie Institution of Washington. He was formerly Chief Illustrator for the United States Geological Survey.

Because the volume rates as a high authority on correct illustration, its own text and examples of illustrations are given the reader on a high quality of paper and with excellent printing and binding.

The author's point of view, or the theme of the work, is expressed in the preface: "The lack of effectiveness shown in the illustrations in many scientific books and pamphlets and their complete inadequacy in some cases, is often apparent; * * * Thus it happens that many good scientific presentations lose much of their deserved effectiveness because of the poorly planned and poorly executed illustrations. * * * The tendency in such cases is to cheapen the written contents of an otherwise well-presented thesis. It is therefore surprising to find crudely prepared illustrations incorporated in any serious book. With the thought not only of helping the scientific writer to select and plan his illustrations but also of aiding the artist whom he may employ, the suggestions in the following pages are offered."

The last sentence rates the volume above the level of the average entomologist who usually is compelled to make his own illustrations. Thus the work is more specifically for professional scientific artists, and for authors who are in a position to employ such.

The text is divided into fifty-eight sections and an appendix of seventeen tables of matter of use to an artist. We cite a few section headings: 1. Purpose and advantages of illustrations; 2. Kinds of illustrations; 3. Plates and figures; 4. Sizes of illustrations; 5. Selection of appropriate illustrative material; 10. Materials used in preparing drawings; 11. Instruments needed; 12. Posing specimens; 13. The drawing of specimens; 19. Color work and colors; 20. Retouching photographs; 26. Making up plates; (Nos. 27 to 50, on map making). 53. Proofreading illustrations; 54. Borrowed and fragile specimens; 55. Copyrighted photographs.

This is a volume that should be in the library of every laboratory where illustrated articles are produced. All biologists who attempt their own illustrations will find it of use. We have left to the last the outstanding feature, the remarkably well chosen illustrations of all kinds used to illustrate the points discussed by the author. It is a very worthwhile volume.—C. H. K.

NOTICE TO MEMBERS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA

The Annual Meeting of the Society will be held in Richmond, Virginia, December 27–29, 1938.

Early reservation of rooms for the December meeting in Richmond is *imperative*, owing to the limited accommodations. The Hotel John Marshall will be the headquarters of the Entomologists, and they have rooms available at the following prices:

Number of Rooms	*Prices*
40 single or double	$3.50–$5.50
40 single or double	4.00– 6.00
20 single or double	5.00– 7.00
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60 twin beds	7.00
50 twin beds	8.00

Make your reservation through: Mr. Leonard K. Baber, Director of Advertising and Sales, Richmond Hotels, Inc., Richmond, Virginia.

JOINT SYMPOSIUM OF ENTOMOLOGISTS AND ECOLOGISTS AT THE RICHMOND MEETING

The Entomological Society of America, American Association of Economic Entomologists, and the Ecological Society of America have arranged a joint symposium for their annual meetings at Richmond, Virginia, in December, on the general topic "Insect Populations." The symposium will be held in the Roof Garden of the John Marshall Hotel on the afternoon of December 27, 1938, at 2:00 P. M. The detailed program is as follows:

JOINT SYMPOSIUM, "INSECT POPULATIONS"

Presiding: DR. V. E. SHELFORD, University of Illinois

1. Insect Population Problems in Relation to Insect Outbreaks.
   ROYAL H. CHAPMAN, Director, Pineapple Producer's Experiment Station, Honolulu, Hawaii.

2. Population Studies of Soil Insects.
   KENNETH M. KING, Dominion Entomological Laboratory, Saskatoon, Saskatchewan, Canada.

3. Populations of Social Insects.
   ALFRED E. EMERSON, Department of Zoology, University of Chicago, Chicago, Illinois.

4. Forest Insect Populations.
   SAMUEL A. GRAHAM, School of Forestry and Conservation, University of Michigan, Ann Arbor, Michigan.

5. Insect Populations in Relation to Biological Control.
   HARRY S. SMITH, Citrus Experiment Station, University of California, Riverside, California.

Negotiations are under way for the publication of the symposium papers as a number of Ecological Monographs. This will be possible if advance orders of 600 copies are guaranteed by the entomologists at a price of $1.00 or less per copy.

BOOK NOTICES

PLANT ECOLOGY, by JOHN E. WEAVER AND FREDERIC E. CLEMENTS, Second Edition, pp. i-xxii and 1-601, 271 text figs, 1 colored map. 1938. Published by McGRAW-HILL BOOK COMPANY, INC., 330 West 42nd St., New York, N. Y. Price $5.00.

After reviewing various types of books which may be of interest to entomologists it is refreshing to browse through a volume on ecology. Spiritually it takes one out of doors. As the authors state, "Plant ecology is pre-eminently a field subject." Professor Weaver is stationed at the University of Nebraska, his main interest being in experimental ecology and particularly in the nature of our glasslands. Doctor Clements is associated with the Carnegie Institution of Washington, lives at Santa Barbara, California, and is mainly responsible for those parts of the book dealing with distribution and succession.

The work is divided as follows: Chapter I. Vegetation; Its Origin, Development, and Structure; II. Methods of Studying Vegetation; III. Plant Succession; IV. Units of Vegetation; V. Initial Causes of Succession; VI. Migration, Ecesis and Aggregation; VII. Competition and Invasion; VIII. Soil in Relation to Plant Development; IX. Reaction and Stabilization; X. Coaction and Conservation; XI. Relation of Underground Plant Parts to Environment; XII. Humidity, Wind and Evaporation; XIII. Temperature; XIV. Light; XV. Plant Response as a Measure of Environment; XVI. Adaptation to Water; XVII. Plants and Plant Communities as Indicators; XVIII. Climax Formations of North America.

In our own training of students for entomology we have laid emphasis on a good foundation in plant ecology. The distribution of insects parallels very closely the distribution of plants. Because of this close tie-up of plant ecology and of applied entomology we recommend "Weaver and Clements" to our entomological readers.

As to binding, paper, printing and illustrations, the volume has the usual high quality of the texts put out by McGraw-Hill.—C. H. K.

INDEX V TO THE LITERATURE OF AMERICAN ECONOMIC ENTOMOLOGY, January 1, 1930, to December 31, 1934, compiled by MABEL COLCORD, edited by E. PORTER FELT. Pages 1-693. Cloth bound. Published by the AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS. For sale by the Secretary, College Park, Maryland. Price $4.50; to foreign countries $5.00 postpaid.

This is the fifth of the Colcord Indices and follows very closely in arrangement the preceding volumes. It includes references to the literature of economic entomology as produced in continental North America, including Alaska, Canada, Mexico, the Panama Canal Zone and in Puerto Rico, Hawaii, Cuba, Guam and some Philippine publications.

It is the key to the literature of economic entomology as produced in that area of the world which has been most advanced in the methods of applied entomology. One can say that as a key volume to this literature it, in itself, is one of the most useful volumes on the subject. In arrangement it is an alphabetic index of the scientific and common names of species discussed in this extensive literature and with these an index to methods. The production of the series of index volumes is a most commendable project. If our own contribution of fifty cents a year helps we are more than glad.

"The increase in dues voted at the Saint Louis meeting provided fifty cents per member towards the publication of Index V. The volume is, therefore, furnished without further charge to members of the Association in good standing." (E. N. Cory, Secretary and Business Manager.)—C. H. K.

FOREST PATHOLOGY, by J. S. Boyce. Pages i-x and 1-600, 6 x 9, 216 illustrations. 1938. Published by the McGraw-Hill Book Co., Inc., New York and London. Price $5.00.

This is the latest addition to the McGraw-Hill "American Forestry Series" of which six volumes have already been published, including "Forest Insects," by R. W. Doane et al. The author is Professor of Forest Pathology at Yale University.

Unlike "Forest Insects" in which the pests are treated in systematic arrangement, the present book is arranged primarily by parts of the tree affected by the pathogen. Thus we find in the body of the book one chapter on root diseases, two on foliage diseases, and eight on stem diseases. Non-infectious diseases, seedling diseases and rots are treated in separate chapters. Three chapters are devoted to deterioration of dead timber and forest products. Other chapters deal with the place and importance of forest pathology in phytopathology, the causes, indications, terminology and classification of diseases (a chapter of definitions), the classification and biology of fungi responsible for diseases, and the principles of forest-disease control. In appendix A the preparation of Bordeaux mixture, lime-sulphur, and wound dressings is described and in B the common names of forest trees are listed alphabetically with the corresponding scientific names. The book is thoroughly indexed in 30 double column pages containing both common and scientific names.

Since the Bureau of Entomology and Plant Quarantine became responsible for the control or eradication of certain plant diseases, forest pathology touches entomologists more closely than it otherwise would. Of tree diseases we are most conscious of the Dutch elm disease. In "Forest Pathology" one can get a general picture of the history and present status of this threatening disease in the five pages devoted to it. The subheadings will serve as a sample of the arrangement of material on other important diseases: history and distribution, hosts, damage, symptoms, causal agency, and control. A whole chapter is devoted to white pine blister rust, the control of which is one of the important projects of the Bureau, though insects are not involved in its dissemination. References to insects as vectors of forest tree diseases are surprisingly few, no doubt because insects have not yet been much studied in this connection. In addition to elm bark beetles as carriers of the Dutch elm disease, our attention is called to the connection between the woolly beech scale and beech bark disease, and between bark beetles and blue stain. Of course insect attack generally weakens trees and makes them more susceptible to invasion by fungi.

Through this book the reviewer satisfied his curiosity about a number of subjects which were vague in his mind; e. g., the notorious chestnut blight, witches' brooms, mistletoe and Spanish moss. He failed to find any information on the effect of the roosting of flocks of starlings or robins on forest trees. The injurious effects produced might be considered a noninfectious disease along with the effects of water deficiency, smoke injury, or mechanical injury.

Well illustrated, chiefly with photographs, this book is not only an excellent text for the student unfamiliar with forest pathology, but it should also be useful to the specialist, who will find a bibliography at the end of each chapter.

—F. L. C.

LAC CULTIVATION IN INDIA. Being a second and revised edition of "A Practical Manual of Lac Cultivation," by P. M. Glover, published in June, 1931, by P. M. Glover. Pages 1-147, 7½ x 9½, 9 text figures, 14 plates (photographs), and 2 colored plates. 1937. Published by Dr. H. K. Sen, Director, Indian Lac Research Institute, Namkum, Ranchi, Bihar, India. Price 2 rupees.

When the reviewer was attempting to transform from a chemist to an entomologist, he told a chemical friend that there are only a few species of insects useful to man, such as the honeybee, silkworm and lac scale. He was much embarrassed to learn that he had omitted insect parasites and predators of insect pests. So he has since been curious to know more about beneficial insects, but until this book was handed to him for review he had read very little about *Laccifer lacca* and lac cultivation.

As the growing of lac is practically restricted to India, this monograph is not essential but would be broadening for American entomologists. It is extraordinarily interesting to read about the cultivation of an insect that would be a pest if it were not for the commercial value of its chief secretory product, lac. The usual point of view of the economic entomologist is reversed; parasites and predators of the lac scale become enemies and hyperparasites and parasites of the predators become beneficial. The book contains all the general information that the casual reader might desire about the biology of the lac scale, its host trees, the artificial infestation of the host, harvesting of the lac incrusted twigs by pruning, the native methods of manufacturing shellac from lac, and the economics of lac production. In addition detailed information and recommendations are given that would be of interest only to the growers of lac. From a technical point of view American entomologists would probably be most interested in the chapter on insect enemies of lac and their control and in the chapter on insect enemies of lac host trees and their control. Attention is called particularly to methods advocated for the control of termites, which are the most serious pests of the lac host trees.

To this reviewer the human side of lac production brought out in this monograph was more interesting than technical details. Although the Indian Lac Research Institute has learned how to produce lac most efficiently, Mr. Glover is pessimistic about the application of this knowledge. Owing to the present low price of lac, he does not encourage the establishment of lac plantations by Europeans who might be intelligent enough to understand and apply his recommendations. With lack production chiefly in the hands of raiyats (peasants), extention work meets a barrier of ignorance, poverty and thievery. Although the volume of lac production is still holding its own, one wonders whether synthetic chemistry will eventually make the lac scale as unimportant as the cochineal scale.

Vernacular names are used extensively in this book and are for the most part defined in a glossary. Scientific and vernacular names of host trees are listed in appendices, but there is no index. The illustrations are generally clear and instructive, but, on the whole, the book is not a good example of the art of printing and binding. Flaws in type are noticeable and the print shows through the thin white paper. The cover is of cardboard and paper. All the errata were not caught in the inserted list. Nevertheless, the reviewer highly recommends this book to anyone who is curious about economic entomology and agriculture in India.—F. L. C.

MEMOIR ON FOSSILS OF THE LATE PRE-CAMBRIAN (Newer Proterozoic) from the Adelaide Series, South Australia, by SIR T. W. EDGEWORTH DAVID AND DR. R. J. TILLYARD, 1936. Pages i-xi and 1-122, 13 pls., linen bound, 8vo. Published by ANGUS & ROBERTSON, LTD., sold by The Australian Book Co., 37 Great Russell St., London W. C. 1. Price, $1.900+.22 duty= $2.12.

In our attempt to get together a complete set of the writings of R. J. Tillyard we came across this volume of interest to anyone curious about the ancestors of insects and their arthropod relatives. The strata of the Adelaide Series are so ancient that to their inhabitants the earliest of the Coal Ages were in a dim and distant future across the vast stretches of time occupied by the Cambrian, Silurian, and Devonian Ages. Since this very early age the area of the earth's crust now called Australia has been very stable so that these early deposits have never been elevated high enough for denudation nor have they been sunk deep enough for their fossils to have been destroyed by heat and pressure.

The first eight brief chapters are by Sir Edgworth David. In them he discusses the geological features of the region and gives a detailed history of the discovery of the remains and the growth of conviction that life could have existed at such a known early age. Eventually sufficient remains were collected to reconstruct in a limited way a picture of seas with reefs of giant almost amorphous algae and mud-banks over which swarmed carnivorous worms and the earliest known arthropods.

Tillyard supplies two chapters on the relationship of the two fossils which are discussed in detail. These represent the arachnoid branch of the Class Arthropoda. They are simpler than the Eurypterida, but resemble them somewhat in their cephalic limbs. Remains of Protozoa (Radiolaria, etc.) and of Annelida are abundant when the remains were finally recognized as such.

This fleeting glimpse into such a distant past gives one a thrill much as did "In Darkest Africa," by Stanley, or did Livingston's writings, when we were a boy. A new and utterly strange world opens up briefly to close as briefly.

—C. H. K.

NATURE STUDY ABOVE AND BELOW THE SURFACE, A Bridge between Amateur and Professional, by H. C. GUNTON. 1938. Pages 1–134, 5½ x 9, 15 charts, 5 tables, 2 photographs, 1938. Published by H. F. & G. WITHERBY, LTD., London. Price, 7 shillings sixpence.

In his preface to this book Dr. C. B. Williams, Head of the Department of Entomology of the Rothamsted Experimental Station, asserts that the growth of professional entomology in the United States has left comparatively few amateurs, whereas in Great Britain the numbers of amateurs are large and possibly increasing. Certainly the character of local entomological meetings has changed in this country, having become dominated by professional entomologists whose specialized interests have subordinated "notes and exhibition of specimens" to a vanishing point on programs. After reading Major Gunton's book we wonder whether the pleasure of entomology is not being forgotten as each of us excavates his own cave of knowledge. Hundreds of young people, who may never become professional entomologists are now receiving instruction in entomology ranging from brief introductions in summer camps to collegiate courses. Those who respond with enthusiasm should be encouraged to make a hobby of entomology, but only in exceptional cases to make a career of it. This can be done only if opportunity is given for amateurs to collaborate with their fellows and with professional entomologists.

The purpose of Major Gunton's book is to show how amateurs can collaborate with professional entomologists and at the same time develop a more satisfying communion with nature in general and with insects in particular than can be attained by a dilettante or mere collector. He believes that purposeful observations in the field, properly made and recorded, can contribute useful information on life history, behavior, and distribution of insects. Himself an engineer and amateur entomologist, he illustrates his thesis by the results of his own observations of butterflies in the field, dealing with species seen in relation to date, location, weather, plants, etc. His observations are summarized in charts, which are rough in appearance as if copied directly from his notebook. He calls attention to the various phenomena that can be observed in the field; e. g., protective resemblance, migration, and variation. The broad knowledge of butterflies displayed by an engineer in this book should shame many a narrow professional entomologist. We know only one amateur in this country, Austin H. Clark, who knows butterflies as Major Gunton does. But Mr. Clark's amateur standing might be questioned.

We are enthusiastic about this book not only because it is a charming and instructive essay, but because it suggests the possibility of popularizing entomology and making the observations of amateurs productive in the development of the ecological and phenogogical aspects of economic entomology. American entomologists are not blind to the desirability of Federal and State insect pest surveys, but, so far, contributions to such surveys are made chiefly by professional entomologists as a by-product of their regular work. The value of such surveys could be tremendously increased, if large numbers of amateurs could be trained and induced to participate in reporting occurrence and abundance of certain species. We recommend Major Gunton's book particularly to professional entomologists who are trying to popularize entomology and to improve insect pest surveys. They should call it to the attention of all who are qualified by education or experience to profit by it and should endeavor to organize reporting by amateur entomologists.—F. L. C.

NOTICE TO MEMBERS AND CONTRIBUTORS

The Annals of the Entomological Society of America, published by the Society quarterly, includes the Proceedings of the Annual Meetings and such papers as may be selected by the Editorial Board.

Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, typewritten, and illustrations finished complete ready for reproduction. Plates must not exceed 4¼x6¾ inches unless intended to fold. Cuts for illustrations are charged at cost to the author. In general, papers to be accepted must be original, complete and previously unpublished. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

The Managing Editor is provided with the most recent address of all paid-up members on record in the Secretary's office for mailing the numbers of the Annals and members failing to receive their numbers should present their complaint to the Managing Editor within four months from the date of the mailing of the issue. After that time the numbers will be furnished only at the regular published rate.

Requests for information as to membership and annual dues of members should be sent to the Secretary-Treasurer, PROF. C. E. MICKEL, Dept. of Entomology, The Farm, University of Minnesota, Saint Paul, Minn.

Communications relating to the ANNALS, and orders for reprints or back numbers, should be addressed to the Managing Editor.

SUBSCRIPTION RATES AND BACK NUMBERS

Beginning January 1, 1939, the regular subscription price for the ANNALS will be $5.00 (U. S. money) in the United States and all other countries. Back volumes and numbers can be secured from the office of the Managing Editor. Volumes I to XXXI, each $4.00, separate issues $1.00 each. Volume XXXII, 1939, will be $5.00, separate issues $1.25 each. Checks, drafts or money orders should be drawn payable to ANNALS ENTOMOLOGICAL SOCIETY OF AMERICA, and addressed to CLARENCE H. KENNEDY, Ohio State University, Columbus, Ohio, U. S. A.

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NOTICE—The Editorial Office wishes to buy a limited number of copies of Vol. XIX (1926), and of No. 3 (Sept., 1930), of Vol. XXIII; four dollars for Vol. XIX and one dollar for No. 3, Vol. XXIII.

CONTENTS OF THIS NUMBER

PAGE

KNULL, JOSEF N. — New Southwestern Buprestidae and Cerambycidae 135

HARDY, D. ELMO—New Therevidae (Diptera) From Utah 144

MICKEL, CLARENCE E.—Synonymical Notes and New Species of Pseudomethoca and Dasymutilla (Mutillidae: Hymenoptera). 147

BURKS, B. D.—A Study of Chalcidoid Wings (Hymenoptera) 157

SMITH, C. F., AND KNOWLTON, G. F.—The Aphid Genus *Microsiphum* in Utah and Idaho 162

FLANDERS, STANLEY E.—Cocoon Formation in Endoparasitic Chalcidoids 167

FORBES, JAMES—Anatomy and Histology of the Worker of *Camponotus herculeanus pennsylvanicus* De Geer (Formicidae, Hymenoptera) 181

WRAY, D. L.—Notes on the Southern Harvester Ant (*Pogonomyrmex badius* Latr.) in North Carolina 196

BRELAND, OSMOND P.—Notes on Sunflower *Callimomidae* with Description of New *Zaglyptonotus* 202

WEBER, NEAL A.—New Ants from Stomachs of *Bufo marinus* L. and *Typhlops reticulatus* (L.) 207

WILLIAMS, C. B.—Recent Progress in the Study of Some North American Migrant Butterflies 211

HAUG, GORDON W.—Rearing the Coccinellid *Hippodamia convergens* Guer. on Frozen Aphids 240

KENNEDY, CLARENCE HAMILTON—*Palaemnema picicaudata*, *P. abbreviata* and *P. brucelli*, New Dragonflies from Ecuador, with Notes on Other Palaemnemas 249

DENNIS, CLYDE A.—The Distribution of Ant Species in Tennessee with Reference to Ecological Factors 267

The Seventh International Congress of Entomology, Berlin, August 15-20, 1938 248

Notice to Members of the Entomological Society of America 309

Joint Symposium of Entomologists and Ecologists at the Richmond Meeting 310

Book Notices 146, 156, 166, 180, 206, 210, 266, 308, 311-314

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